L.2.2004-249
University of Alberta Library
1620 3682066 8

SCIENCE 9

odule 5

Space Exploration

Learning
Technologies
Branch

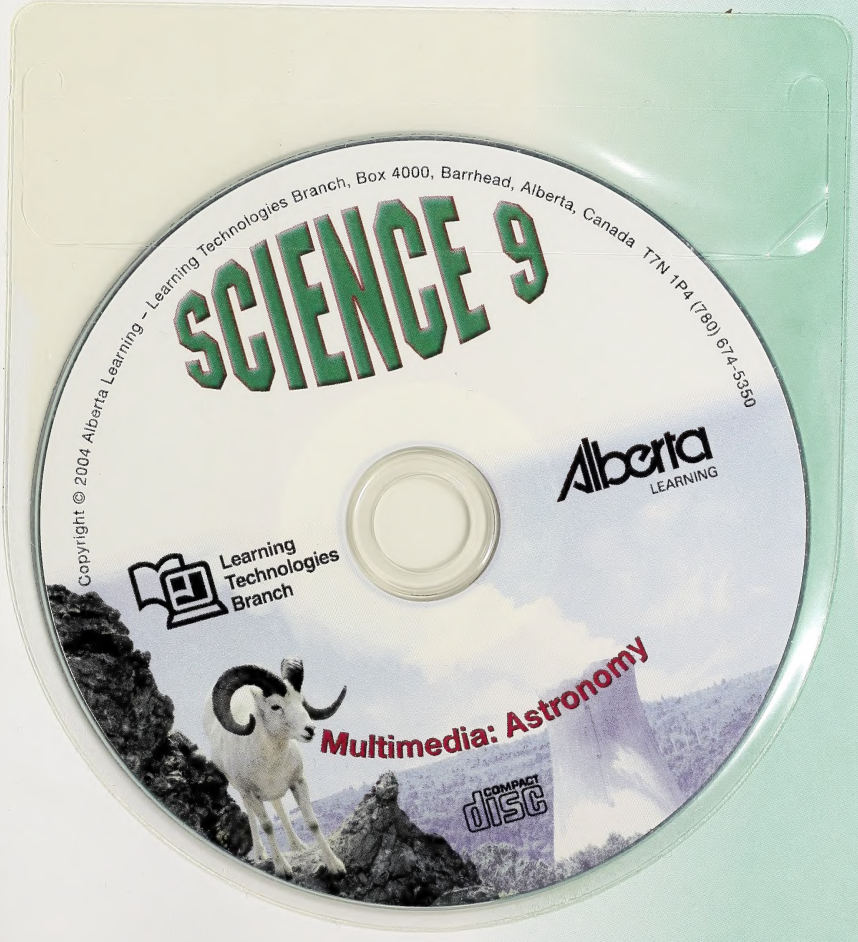
Alberta
LEARNING

Digitized by the Internet Archive
in 2016 with funding from
University of Alberta Libraries

https://archive.org/details/science905albe

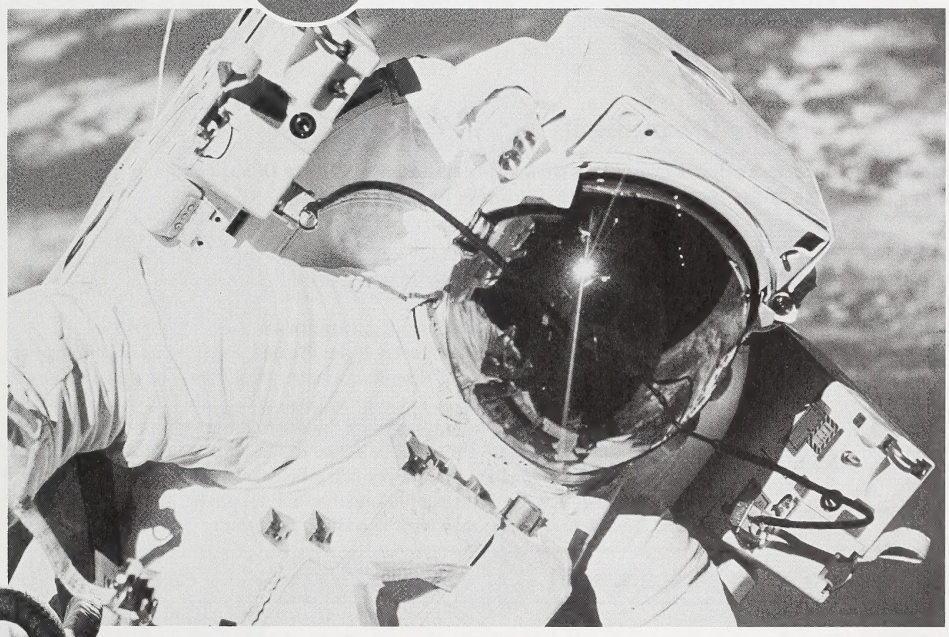
Multimedia: Astronomy CD

- Circumpolar Motion
- The Summer Constellations
- The Winter Constellations
- The Celestial Sphere
- Kepler's Three Laws of Planetary Motion
- Tracking a Comet
- Planetary Orbits
- Spectroscopy and Stellar Identification
- Our Home in the Milky Way
- The Interior of the Sun
- A Renewed Spirit of Discovery



SCIENCE 9

Module 5 Space Exploration



Science 9
Module 5: Space Exploration
Student Module Booklet
Learning Technologies Branch
ISBN 0-7741-2598-5

The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	

You may find the following Internet sites useful:

- Alberta Learning, **http://www.learning.gov.ab.ca**
- Learning Technologies Branch, **http://www.learning.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.learning.gov.ab.ca**

The use of the Internet is optional. Exploring the electronic information superhighway can be educational and entertaining. However, be aware that these computer networks are not censored. Students may unintentionally or purposely find articles on the Internet that may be offensive or inappropriate. As well, the sources of information are not always cited and the content may not be accurate. Therefore, students may wish to confirm facts with a second source.

Copyright © 2004, Alberta Learning. This resource is owned by the Crown in Right of Alberta, as represented by the Minister of Learning, Alberta Learning, 10155 – 102 Street, Edmonton, Alberta, Canada T5J 4L5. All rights reserved.

No part of this courseware may be reproduced in any form, including photocopying (unless otherwise indicated), without the written permission of Alberta Learning. This courseware was developed by or for Alberta Learning. Third-party content has been identified by a © symbol and/or a credit to the source. Every effort has been made to acknowledge the original source and to comply with Canadian copyright law. If cases are identified where this effort has been unsuccessful, please notify Alberta Learning so corrective action can be taken.

THIS COURSEWARE IS NOT SUBJECT TO THE TERMS OF A LICENCE FROM A COLLECTIVE OR LICENSING BODY.

UNIVERSITY LIBRARY
UNIVERSITY OF ALBERTA

WELCOME to Science 9!

It is recommended that you work through the modules in order because the concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.

Module 1 Biological Diversity

Module 2 Matter and Chemical Change

Module 3 Environmental Chemistry

Module 4 Electrical Principles and Technologies

Module 5 Space Exploration

Module 1 contains general information about the course components, additional resources, icons, assessment, and strategies for completing your work. If you do not have access to Module 1, contact your teacher to obtain this important information.

Contents

Resources 6

Before You Begin 6

Icons 7

Module Overview 8

Assessment 9

Planning Ahead 10

Section 1: Earth Among Celestial Objects 11

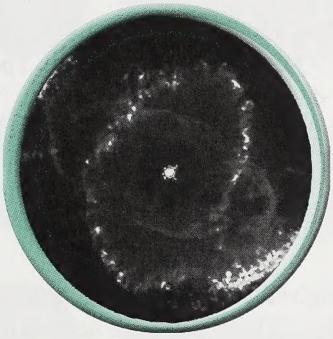
Lesson 1: Naked-Eye Observations 12

Lesson 2: A Better View with Optics 19

Lesson 3: Wrap-up 23

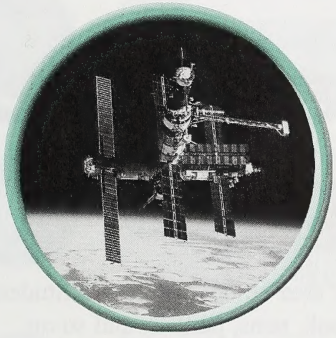
Section 1 Conclusion 24

Section 2: Advanced Technologies 25



Lesson 1: The Spectroscope 26
Lesson 2: Bigger and Smarter Telescopes 32
Lesson 3: What Channel Is That? 36
Lesson 4: Wrap-up 38
Section 2 Conclusion 39

Section 3: Satellites and Spacecraft 40



Lesson 1: Above the Atmosphere 41
Lesson 2: The Solar System Up Close 46
Lesson 3: People in Space 50
Lesson 4: Wrap-up 54
Section 3 Conclusion 55

Module Summary 56

Module Review 56

Appendix 57

Glossary 58
Suggested Answers 60
Image Credits 76

Resources

Textbook

To complete the course, you need the textbook *ScienceFocus 9*.

Multimedia

Attached to Student Module Booklets in this course are CDs titled *Science 9 Multimedia* and *Science 9 Multimedia: Astronomy*. These CDs contain multimedia segments designed to help you better understand particular concepts presented in this course. Ask your teacher or home instructor if you need help using these CDs.

Materials and Apparatus

A list of materials and apparatus is given on the Planning Ahead page of each Student Module Booklet. These items are needed to complete the module. Some of the materials and apparatus may be provided at your local school lab. If you don't have access to a school lab, you will need to get the loan kit. Talk to your teacher for more information.

Before You Begin

Organize your materials and work area before you begin: Student Module Booklet, textbook, notebook, pens, pencils, and so on. Make sure you have a quiet area in which to work, away from distractions.

Because response lines are not provided in the Student Module Booklet, you'll need a looseleaf binder or notebook to respond to questions and complete charts. It's important to keep your lined paper handy as you work through the material and to keep your responses together in a notebook or binder for review purposes later.

Refer to the Planning Ahead page for directions on what you need to do before you start this module.

Good luck!

Icons

This is one of five Student Module Booklets for Science 9. As you progress through this module, you will meet several icons.

Do Ahead

Some preparation must be started well ahead of the activity or investigation. E.g., start the seedlings for the investigation in Lesson 3.

Teacher or Home Instructor

The teacher or home instructor should be contacted for help, approval of some procedure, or checking answers.

Assignment Booklet

Work needs to be done in an Assignment Booklet.

Safety

You must be very careful when you see this symbol.

Textbook

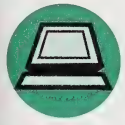
A reference is made to *ScienceFocus 9*, the student textbook for this distance learning course.

Internet

This is a reference to the Internet. **Note:** Any Internet website given is subject to change.

Multimedia

This is a reference to the *Science 9 Multimedia* CDs.



Computer

You will need to work with a computer when you see this symbol.

Module Overview

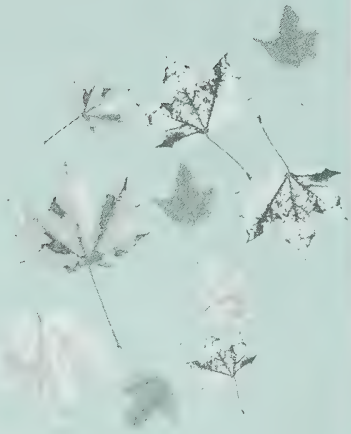
Do you remember being outside on a clear, still night, with no streetlights nearby? You could have been camping or merely walking from the car to your home. Then you may have looked at the night sky and wondered, "What's really up there in space?"

You wouldn't have been alone in your curiosity. People have always been interested in the stars and other objects. Nowadays, modern technology plays an important role in exploring space and finding out what's up there.

Section 1
Earth Among Celestial Objects

Section 2
Advanced Technologies

Section 3
Satellites and Spacecraft



In this module you will study not only outer space itself, but also the use of modern technologies in the exploration of outer space. You will see how science and technology interact. Technologies for space exploration contribute to the understanding of the solar system and the universe. As a further benefit, these technologies also serve practical purposes on Earth.

Check out pages 352 to 355 of the textbook. You'll see what's coming up in this module.

Assessment

The booklet you are presently reading is the Student Module Booklet. It will show you, step by step, how to advance through Module 5: Space Exploration.

This module, Space Exploration, has three sections. Within each section your work is grouped into lessons. Within the lessons there are readings, investigations, activities, and questions for you to do. By completing these lessons you will discover scientific concepts and skills, develop a positive attitude toward science, and practise or apply what you have learned.

Suggested answers in the Appendix of this Student Module Booklet will provide you with immediate feedback on the answers to questions in the lesson. Your teacher or home instructor will also provide you with feedback on your progress through the module.

At several points in this module you will be directed to an accompanying Assignment Booklet. Your grading in this module is based on the assignments you submit for assessment. In this module you are expected to complete three section assignments and a Final Module Assignment.

The mark distribution is as follows:

Assignment Booklet 5A	
Section 1 Assignment	46 marks
Section 2 Assignment	41 marks
Assignment Booklet 5B	
Section 3 Assignment	33 marks
Final Module Assignment	52 marks
TOTAL	172 marks

Planning Ahead

Here is a list of materials and apparatus you will need to complete this module.

Section 1

- ❑ a variety of round objects to represent planets
- ❑ cardboard
- ❑ a geometry compass
- ❑ heavy paper or cardboard
- ❑ paper
- ❑ a pair of scissors
- ❑ a paper clip
- ❑ pins
- ❑ a protractor
- ❑ string
- ❑ tape
- ❑ a tape measure or a ruler
- ❑ a wide drinking straw
- ❑ a small mirror
- ❑ two round-headed paper fasteners

Section 2

- ❑ an AM/FM radio
- ❑ cardboard
- ❑ coloured pens or pencils
- ❑ measuring tape
- ❑ plastic
- ❑ a protractor
- ❑ a ruler
- ❑ wool
- ❑ a spectroscope

Section 3

- ❑ No extra materials are needed for this section.

If you have access to the Internet, you may want to check out some of the links for this module ahead of time. Go to the following site:

http://www.mcgrawhill.ca/school/booksites/sciencefocus+9/student+resources/toc/index.php

Do you want a head start on satellites and space travel? Go to this site:

http://science.howstuffworks.com/satellite.htm

Are you curious about what Canada is doing in space? Go to this site:

http://www.space.gc.ca/

Section 1

Earth Among Celestial Objects

Have you ever used a telescope or a pair of binoculars? Then you know how much an optical device can improve your viewing of objects in the distance.

New optical devices allowed people to see how Earth fit in with other celestial bodies in the solar system. These devices changed the status of Earth among the planets and the Sun.

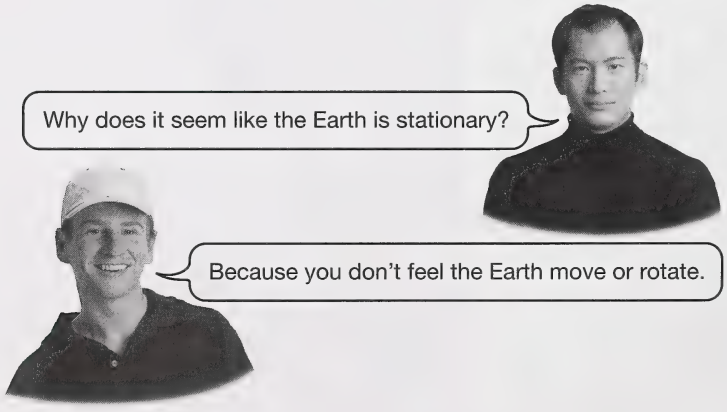
In this section you will study the development of technological devices and methods used to view the universe. You will gain an appreciation for the close ties between technologies and the evolution of the model of the solar system.

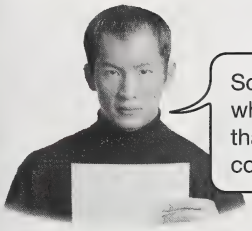
Lesson 1: Naked-Eye Observations

Imagine that you look at the sky every night and record your observations. Would you ever come to the conclusion that the Earth is round and revolves around the Sun? Not likely.

With no optical instruments to observe the sky, people were limited in what they could find out. Many models were developed. Many of the early models, including the **Earth-centred model**, considered Earth as the stationary centre of the universe.

Earth-centred model: a model of the universe that places Earth at the centre, with the Sun, Moon, and planets revolving around it





So it's quite understandable that people held on to a model where Earth was the stationary centre. They didn't understand that movement isn't an absolute quality—movement must be considered from a **frame of reference**.

It's the objects in the sky that seem to move. For example, the Sun seems to move through the sky from east to west.

Frames of Reference

In the northern hemisphere, circumpolar motion is the apparent motion of stars around Polaris, the pole star.

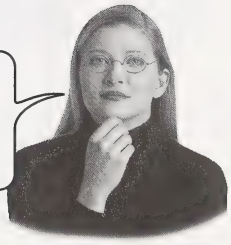
Play the *Science 9 Multimedia: Astronomy* CD on your computer. On the computer screen, select the title "Circumpolar Motion." You can see that the constellations, or groups of stars, maintain their shapes as they move around Polaris. The clock illustrates that the stars make one complete rotation each day.

The photograph from "Figure 5.3" on page 357 of the textbook is a time exposure. When it was taken, the camera shutter was left open for almost an hour. Each star leaves an arc rather than a point. What does the formation of arcs show?

frame of reference: a set of axes or a co-ordinate system for the purpose of assigning positon and time to events

The arcs show the motion of the stars.

Yes, using the Earth as a frame of reference, it's the stars that are moving. But you could also consider the Earth to be moving from the stars' point of view. It depends on the frame of reference.



Turn to page 356 of the textbook and read "Frames of Reference."

1. Name the two frames of reference illustrated in "Figure 5.2."

Compare your response with the one in the Appendix on page 60.

Some types of puppet figures are remotely manipulated from above by strings or threads attached to a control. Remote manipulation is important in space technology and is the topic of the next "Going Further."

Going Further

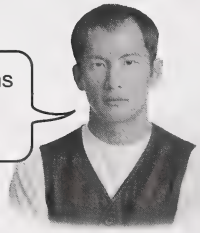
The Unit 5 Project in the textbook helps you plan and create your own "remote manipulator." Read "Looking Ahead" on page 355 of the textbook to find out how to prepare for this project.

These "Going Further" sections are for those of you who want to do extra in-depth work. There are lots of interesting topics to work on.

Ancient Views

When I look at the night sky, am I seeing the same patterns that were viewed in ancient times?

Yes, the constellations named by ancient civilizations are still visible today. Viewing them may give you a sense of connection with ancient times and people.



Turn to pages 357 and 358 of the textbook and read "What Our Ancestors Saw" and "Ancient Legends."

2. Why is a different set of stars visible each month?

3. How do the motions of the Moon and the Sun differ from the stars?

4. Why did the ancient Greeks only identify five of the planets?

Compare your responses with those in the Appendix on page 60.

Do you want to become more familiar with constellations in the sky? Maybe you want to know more about the legends behind constellations. Then complete "Going Further."

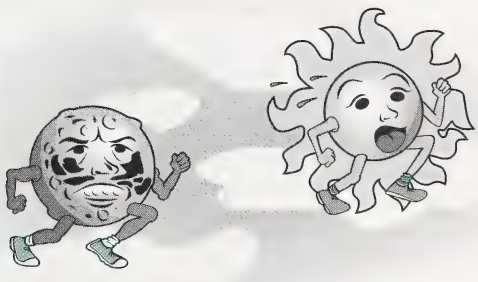
Going Further

Play the CD titled *Science 9 Multimedia: Astronomy*. Select "The Summer Constellations" or "The Winter Constellations." The visible stars change over the seasons. Pick the title that corresponds to the season you are in. The presentation will then be about stars that are actually visible in the night sky.

Note: The word *Inuit* means *people*.

As you look at the night sky in awe, it's not difficult to imagine that it inspired the creation of legends. Humans used legends to explain mystical phenomena. Legends gave a perspective on the nature of space and the behaviour of bodies in it. One legend about space comes from a group of Inuit living in Greenland.

Malina, the Sun goddess, and her brother, the Moon god Anningan, lived together. One day they got into a terrible fight and Malina spread dirty, black grease all over her brother's face. In fear, she ran as far as she could into the sky and became the Sun. Anningan chased after her and became the Moon.



Anningan often forgets to eat, so he gets thinner as the days go by. Every month, the Moon disappears for three days while Anningan eats. He then returns to chase his sister once again.

This eternal chase makes the Sun alternate in the sky with the Moon.

In the following "Going Further" you may explore some of the legends developed to explain the heavens.

Going Further

Legends are typically developed in cultures to help make sense of the world, unknown phenomena, and events that are difficult to explain. Do some research into the legends of the stars! Try the "Find Out Activity: Pleiades Legends" on page 358 of the textbook.

Co-ordinates of the Sky

To locate an object in the sky, it's necessary to select a frame of reference. In the case of celestial objects you have two options—you can choose Earth or the stars as a frame of reference.

Using Earth as the frame of reference, you locate the object relative to your position on this planet. With the stars as the frame of reference, you locate the object's position from the stars' point of view.

Turn to pages 359 and 363 of the textbook and read "Sky Co-ordinates" and "The Stars as a Frame of Reference."

Do you want to know more about a co-ordinate system in which the distant stars remain in fixed positions? The next "Going Further" is about such a co-ordinate system.

Going Further

Imagine a sphere at a great distance from the Earth. On this sphere, the Sun and planets follow a path called the *Ecliptic*. While Earth rotates within the sphere, stars remain in fixed positions.

What's so useful about a co-ordinate system based on this sphere? It's useful because the stars' co-ordinates stay fixed over time.

Play the CD titled *Science 9 Multimedia: Astronomy*. Once the CD opens on the computer screen, select "The Celestial Sphere."

5. The Earth and the stars can each be used as a frame of reference.

   a. Name the co-ordinates used to fix a celestial body relative to Earth.

   b. Which frame of reference is being used when you describe a celestial object as being near the constellation of Orion?

6. Do the "Practice Problems" on page 359.

Compare your responses with those in the Appendix on page 60.

In the following activity you will construct and use a device to locate the position of the Sun at various times of the day.

Investigation 5A Where in the Sky?

Refer to the "Inquiry Investigation" on page 360 of the textbook.

Carry out the steps of "Procedure" in "Part 1." **Note:** Alternatively, you may glue onto the cardboard a circle drawn on a piece of paper.

7. Answer questions 1 and 2 from "Analyze" on page 361.

Carry out the steps of "Procedure" in "Part 2."

Note the safety precautions for this activity!

8. Answer questions 1 to 4 from "Analyze" on page 362.

Compare your responses with those in the Appendix on page 61.

end of investigation

Earth or Sun?

What is at the centre of the bodies that you see moving in the sky? It does seem that celestial bodies move around the Earth. So, it is understandable that the solid Earth was once considered the body around which everything else moved. In an Earth-centred model, the Earth is the frame of reference used to describe the motion of celestial bodies. But eventually, it was seen that Earth was not the most useful frame of reference to describe and explain celestial events.

Turn to pages 363 and 364 of the textbook and read "The Earth-Centred Model" and "The Sun-Centred Model."

9. Describe Aristotle's model of the universe.

10. Ptolemy proposed an alternative to Aristotle's model. What shortcoming did this model attempt to address?

11. Who proposed the heliocentric model? How was it different from Ptolemy's model?

12. List some of the objections people had to the Copernican model.

Compare your responses with those in the Appendix on page 62.

13. Turn to page 365 of the textbook and answer questions 1 to 4 and question 6 of "Topic 1 Review."

Compare your responses with those in the Appendix on page 62.

Looking Back

In this lesson you studied how people, with limited technologies, developed models of the universe to explain celestial events.

Turn to Assignment Booklet 5A. Complete questions 1 to 6 from Section 1.

Lesson 2: A Better View with Optics

Do you wear glasses or use a magnifying glass? Then you know how optical devices can help you learn about your surroundings. Without such optical devices your exploration would be limited. Astronomers also depend on optical devices.

The invention of the telescope opened up new worlds to astronomers as they peered through them into the night sky.

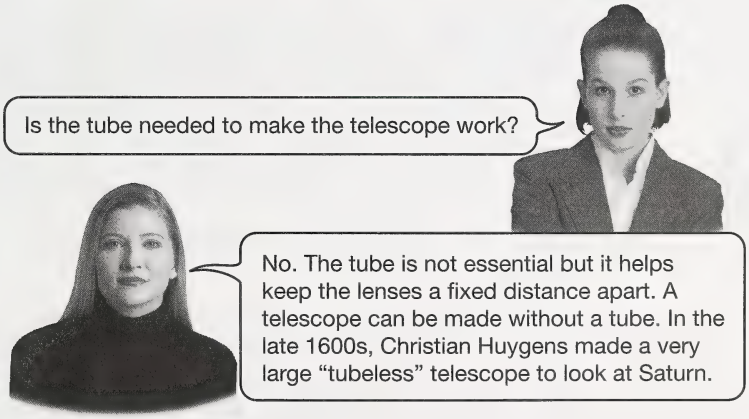
In this lesson you will investigate how the use of the telescope to observe the sky led to a revolution in astronomy. This revolution changed the way people envisioned the universe.

Telescopes

convex lens: a lens that is thicker in the middle than around the edges

telescope: a device used to magnify objects at great distances

When you studied optics in Science 8, you found that a pair of **convex lenses** at each end of a tube could make a **telescope**.


Is the tube needed to make the telescope work?
No. The tube is not essential but it helps keep the lenses a fixed distance apart. A telescope can be made without a tube. In the late 1600s, Christian Huygens made a very large "tubeless" telescope to look at Saturn.

Turn to page 369 of the textbook and read "Did You Know" to see how Christian Huygens made a telescope that was tens of metres long. And he did this without a tube to hold the lenses!

Turn to page 366 of the textbook. Read the introductory paragraph of "Topic 2" and also read "Telescopes."

1. Who invented the telescope?

2. A simple telescope is made of two convex lenses. The _____ lens is at the front of the telescope and the _____ lens is near the eye of the user.

Turn to page 367 and read "Galileo's Approach to Inquiry." Examine the photographs on pages 366 and 367.

3. Answer question 1 in the "Pause and Reflect" on page 367.

4. What evidence helped Galileo conclude that the Moon has craters and mountains?

Turn to page 370 of the textbook and read "Resolving Power." This reading goes to the end of the page.

5. How does a refracting telescope differ from a reflecting telescope?

6. What determines the resolving power of a telescope?

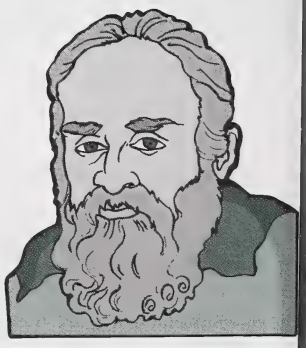
Compare your responses with those in the Appendix on page 63.

In the following "Going Further" you will see how to make a simple telescope with different optical properties.

Going Further

Complete "Inquiry Investigation 5B: Construct and Test a Telescope" on pages 368 and 369 of the textbook.

Astronomy and Telescopes



Galileo Galilei is credited with improving the refracting telescope. He was the first person to use it as an astronomical tool. The results of his observations led to a societal and scientific revolution. That's because his work confirmed the Copernican model. It also acted as a platform from which others could launch their own studies.

Turn to page 371 of the textbook and read "Copernicus's Sun-centred Revolution Continues."

Kepler described the shape of the orbit of planets. But his description of planetary motion did not stop there. Find out more about Kepler's contribution in the next "Going Further."

Going Further

Aside from recognizing that each planet has an elliptical orbit, Kepler described the various speeds of a planet as it moves through different parts of its orbit. Furthermore, he described a relationship between the radius of a planet's orbit and the time the planet takes to go around the Sun. Kepler's description of planetary motion can be described in these three laws:

- Kepler's first law. The planets move in elliptical orbits with the Sun at one focus.
- Kepler's second law. A line joining any planet to the Sun sweeps out equal areas in equal lengths of time.
- Kepler's third law. The squares of the periods of revolution of the planets are directly proportional to the cubes of their average distances from the Sun.

Play the *Science 9 Multimedia: Astronomy* CD. Select "Kepler's Three Laws of Planetary Motion."

Note: You are not expected to enter Kepler's laws or do any calculations. Simply look at the animations for a visual representation of Kepler's three laws.

Turn to page 372 of the textbook and read "Universal Gravitation" to find out why the orbits of planets are shaped as ellipses. Then find out about a celestial body that follows a very elongated elliptical orbit around the Sun—read "Did You Know?" on page 374.

7. How did Johannes Kepler improve the Copernican model of the solar system? Whose data did he use?

8. Describe how Isaac Newton's law of universal gravitation explains planetary motion in the solar system.

Compare your responses with those in the Appendix on page 63.

In the following activity you will investigate the geometric characteristics of an ellipse.

Find Out Activity: Draw an Ellipse

Refer to the activity on page 371 of your textbook.

Carry out the steps of "Procedure."

9. Answer the "What Did You Find Out?" questions.

Compare your responses with those in the Appendix on page 63.

Galileo insisted on supporting scientific explanations with evidence provided by observations. Kepler and Newton pioneered the use of mathematics in the development of models and theories. The use of observation and mathematics led to a whole new way of doing science.

The new way of science led to models that could be used to predict events. For example, the new model of the solar system from Kepler and Newton provided insight into the appearance of comets and meteors in the sky.

Play the *Science 9 Multimedia: Astronomy* CD on your computer. View "Tracking a Comet." Be sure to read the description that is included with this **applet**.

applet: a short application program especially for performing a simple, specific task

In the following "Going Further," check out the accuracy of predictions based on the new way of doing science.

Going Further

Complete "Find Out Activity: Predicting Events" on page 372 of your textbook.

A great amount of numerical data has been collected about the solar system and the universe.

Play the CD titled *Science 9 Multimedia: Astronomy*. View the animation called "Planetary Orbits." You can see a wide variation in the speed of planets that orbit the Sun.

In the following investigation you will apply some of this information to construct a scale model.

Refer to the "Problem-Solving Investigation" on page 373 in your textbook.

Follow the steps of "Plan and Construct." If possible, have your friends, family, or home instructor participate in the activity with you.

10. Answer question 2 of "Evaluate."

Compare your response with the one in the Appendix on page 63.

end of investigation

11. To test your understanding of the concepts in this lesson, answer questions 1, 2, 6, and 7 from "Topic 2 Review" on page 374 of your textbook.

Compare your responses with those in the Appendix on page 64.

Looking Back

In this lesson you investigated how improvements in technology and data analysis led to the development of a new model of the solar system.

Lesson 3: Wrap-up

To review the concepts covered in this section, complete the following questions. Turn to page 375 in the textbook and answer questions 1 to 3 and question 7 of "Wrap-up: Topics 1 to 2."

Check your answers with your teacher or home instructor.

Section 1 Conclusion

In this section you investigated the development of optical and measurement technologies. These technologies led to better observations and interpretations of the number, position, and motion of celestial bodies near Earth. You saw how these findings led to the present-day model of the solar system. The evolution of this model gave you an appreciation for the role of technologies in the advancement of science.

The Earth is now viewed as one of many bodies revolving around the Sun. The contemporary model of the solar system allows you to view the Earth from an "out of this Earth" vantage point—at least in your mind's eye.

Modern day technologies for space exploration allow pictures to be taken of the Earth from outer space. These pictures confirm views of Earth that had only been present in the minds of people.

Turn to Assignment Booklet 5A. Complete questions 7 and 8 from Section 1.

Section 2

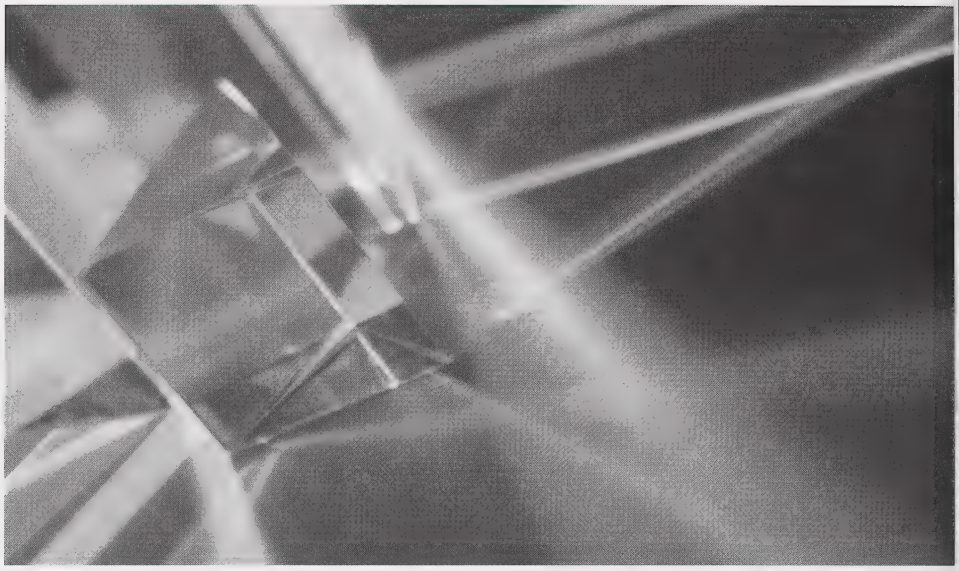
Advanced Technologies

The pictured "Cat's Eye Nebula" is located in a northern constellation called Draco. Its light takes 3000 years to reach Earth. This image was made by combining three images taken by the Hubble Space Telescope. The pattern in the image is due to expanding shells of luminous gas.

Through a small optical telescope, such objects look like planets. Only advanced technology allows the viewing of expanding shells of luminous gases.

In this section you will explore advanced technologies that have been developed to receive and process data about the universe. You will investigate the use of spectroscopes and computer-controlled optical and radio telescopes. You will also study the kind of inferences scientists make from the data collected with these modern tools.

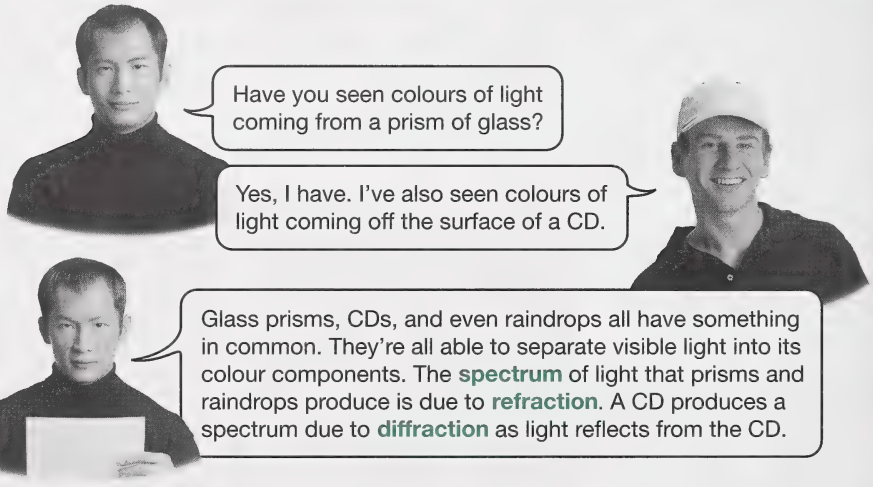
Lesson 1: The Spectroscope



spectrum: a series of colours formed when a beam of light is separated (as by refraction or diffraction) so that its component wavelengths are arranged in order

refraction: the bending of light due to a change in speed as light passes into a more dense or less dense medium

diffraction: the bending of light as it passes through narrow slits


Have you seen colours of light coming from a prism of glass?
Yes, I have. I've also seen colours of light coming off the surface of a CD.
Glass prisms, CDs, and even raindrops all have something in common. They're all able to separate visible light into its colour components. The spectrum of light that prisms and raindrops produce is due to refraction. A CD produces a spectrum due to diffraction as light reflects from the CD.

Splitting light into its components helps scientists—they can then analyze light by its spectrum. The analysis of light coming from light-producing objects reveals many things about the objects giving off the light. The analysis of light from distant celestial objects, such as stars, allows scientists to make inferences about the objects.

Turn to page 376 of the textbook and read the introductory paragraph of "Topic 3." Also read "Spectral Lines."

Spectroscopy

Analyzing light spectra has allowed scientists to identify the presence of elements and compounds of a body emitting light. Such analysis is particularly useful in astronomy, but it is also used in analytical chemistry and forensics.

Turn to pages 376 and 377 of the textbook. Read "Spectroscopy: The Science of Colour."

1. Who first demonstrated that white light is really a combination of all the colours? How was this demonstrated?

2. List three types of spectra and the light source that produces them.

3. What is the significance of the dark lines that Joseph von Fraunhofer discovered in the solar spectrum?

4. Who investigated the spectra of elements? What was the conclusion?

Play the *Science 9 Multimedia: Astronomy* CD on your computer. View the title "Spectroscopy and Stellar Identification." Watch the formation of an emission spectrum, a continuous spectrum, and an absorption spectrum. Also see some common absorption spectra of elements.

Note: You can see some common absorption spectrums of elements by selecting "Classify Spectra Activity." When you select this title, a wrap-up activity is presented. You are not expected to enter answers for the questions.

Turn to page 378 of the textbook and read "Diffraction Gratings."

5. What advantage does a diffraction grating have over a prism in producing a spectrum?

Compare your responses with those in the Appendix on page 64.

In the following activity you are challenged to predict the type of spectrum a given light source produces. You will also analyze spectral data.

Investigation 5D Identifying Spectra

Refer to the "Inquiry Investigation" on page 379 of the textbook.

Do not look at the Sun directly or with any optical instrument.

Read the introductory information and record your prediction of spectrum types. Carry out the steps of "Procedure."

6. Answer questions 1 to 4 from "Analyze" and "Conclude and Apply."

Compare your responses with those in the Appendix on page 65.

end of investigation

Spectral Analysis

Turn to page 380 of the textbook and read "Spectroscopy for Astronomers." In the reading you'll find out how astronomers have used spectroscopy to determine the composition of glowing celestial matter.

7. On what basis do astronomers infer the presence of a particular element on a star?

Compare your response with the one in the Appendix on page 65.

In the following investigation you will use the methods employed by scientists to identify the elements from which stars are made. You will compare the known spectra of elements to star spectra.

Investigation 5E Long-Distance Chemistry: Using Spectral Analysis to Identify Star Composition

Refer to the "Think and Link Investigation" on page 381 of the textbook.

Carry out the steps of "What to Do."

Note: The solar spectrum is actually very complex. A careful analysis of the thousands of lines in its true spectrum reveals that at least two-thirds of all elements are present in the Sun's atmosphere. A greatly simplified version has been created for the purposes of this investigation.

8. Answer questions 1 to 6 of "Analyze."

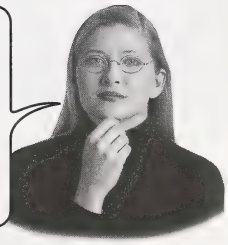
Compare your responses with those in the Appendix on page 65.

end of investigation

The Doppler Effect

When you look up at the night sky the stars seem to be in fixed positions. Is there some way to determine whether they are moving toward Earth or away from Earth?

Yes, there is a technique to determine the speed of light-emitting objects. Think of the behaviour of sound from a moving object. You may have noticed changes in the sound from a vehicle as it comes toward you, passes, and drives away. The variation in the pitch is known as the Doppler effect. Light from moving objects also exhibits the Doppler effect. Instead of changes in pitch, light changes in colour.



Read "The Doppler Effect" and "An Amazing Tool!" on pages 382 and 383 of the textbook. Find out the significance of the Doppler effect in astronomy. Study all the diagrams carefully. Don't forget to read the "Did You Know?" margin features.

9. a. How do astronomers determine whether a star is moving toward or away from Earth?

b. Can they determine its speed in this way?

10. a. How can stellar distances to nearby stars be measured?

b. What is a definition for this phenomenon?

Compare your responses with those in the Appendix on page 66.

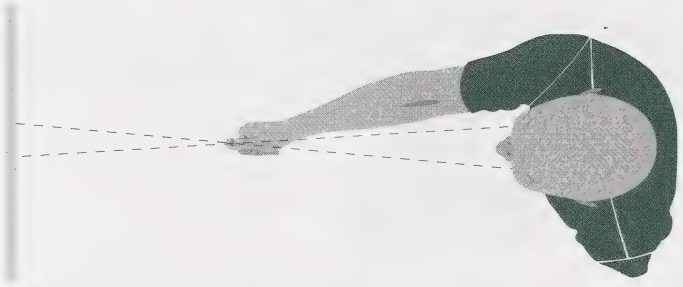
Parallax—A Way to Measure Distance

The ancient view of the night sky was that all the stars were attached to the surface of a giant transparent sphere that centred on Earth. But astronomers came to observe that as Earth and the Sun moved with respect to each other, some stars shifted in position relative to the others. This apparent shifting of position suggested that the stars were at various distances from Earth—they could not be on one celestial sphere.

parallax: the apparent shift or the difference in apparent direction of an object as seen from two different points

Astronomers came to realize that this shifting occurred because of **parallax** as the Earth moved from one side of the Sun to the other.

"What is parallax?" is a reasonable question to ask.



Parallax is especially used to refer to the angular difference in direction of a celestial body as measured from two points on Earth's orbit.

You can experience parallax in your own immediate environment. Hold your arm out in front of you with your thumb pointing up. Close one eye and focus on a picture on the wall behind your thumb. Switch eyes without moving your thumb. You will notice that the picture seems to have changed position relative to your thumb.

Now, have someone else hold his or her thumb far away from you but close to the picture. Look at this thumb through one eye and then the other. The picture will show little, if any, movement. The apparent shift in the picture is due to parallax.

For astronomical observations, the viewing distances must be separated much farther than your eyes are. Opposite sides of Earth's orbit around the Sun are used as viewing positions. Then the parallax of "close" celestial objects can be used to indicate their distance away. However, distant objects in the sky show almost no parallax. Therefore, parallax cannot be reliably used to indicate their distance.

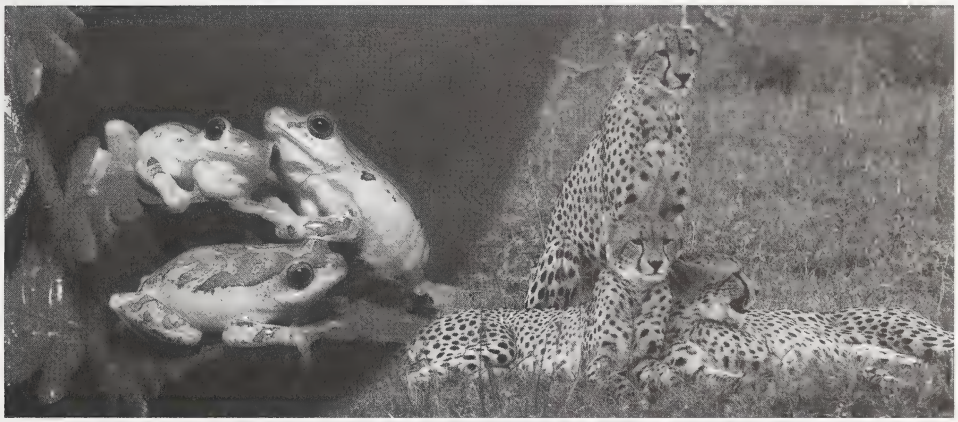
11. To test your understanding of the concepts in this lesson, answer questions 1 to 4 of "Topic 3 Review" on page 384 of your textbook.

Compare your responses with those in the Appendix on page 66.

Going Further

Just outside the visible spectrum, and beyond red light, is infrared light. When you look at living things with infared light, you can distinguish between warm-blooded and cold-blooded animals. Infrared light even shows how well feathers and fur insulate animals. Infrared light also reveals important features of celestial objects. Infrared astronomy forms an important branch of astronomy. For more information on infrared astronomy, explore the following site:

http://coolcosmos.ipac.caltech.edu/



Looking Back

Spectral analysis has allowed people to infer the composition of stars and the movements of galaxies beyond our own. In this lesson you studied spectral analysis and its application in astronomy.

Turn to Assignment Booklet 5A. Complete questions 1 to 3 from Section 2.

Lesson 2: Bigger and Smarter Telescopes

When Galileo first aimed his telescope at the sky, he was able to distinguish details of the Moon and some of the planets. But the distant stars remained tiny specks.

Telescopes needed to be improved.

How was telescope technology improved? What were some of the results achieved with this advanced technology? The technological changes occurred in the following three areas:

- an increase in the diameter and length of the tube
- better optics (mirrors and lenses)
- the use of computers to adjust and connect telescopes, filter input, and correlate data

Your textbook describes the technological features of current telescopes. It lists the related astronomical discoveries.

Turn to pages 385 and 386 of the textbook and read the introductory paragraph for "Topic 4." Then read "New Discoveries," "Combining Telescopes," and "Adaptive Optics."

1. Gerald Kuiper discovered methane gas on Titan, a moon of Saturn. Can you suggest the method he used to do this?

2. What is the advantage of linking two telescopes by computer?

3. How does the "adaptive optics" technology function when it's applied to telescopes?

Compare your responses with those in the Appendix on page 66.

Have you ever been surprised by how many more stars you can see in the country than in the city? In urban areas, light from streetlights, buildings, and vehicles makes it difficult to see any but the brightest and closest stars. Astronomers refer to unwanted light as light pollution.

To avoid light pollution, telescopes are usually found in remote locations or, as in the case of the Hubble Telescope, in space. These telescopes can view stars that are far from Earth.

Stellar Distances

The distance to celestial objects from Earth has intrigued people for thousands of years. Modern telescopes can pinpoint the direction to the stars. With the direction to a star from two widely separated positions, **triangulation** can determine the stars' distance very accurately—as long as the star is not too far away.

triangulation: a method of measuring distance by constructing an imaginary triangle between an observer and an object whose distance is to be estimated

This is also known as the parallax technique.

Turn to pages 387 to 389 of the textbook and read "Distance to the Stars." Study the explanation of triangulation carefully so that you will be able to use this description. Include the margin features in your reading.

4. List the measurements required to determine the distance to an object by triangulation.

5. Why was Christian Huygens' approximation of the distance to Sirius incorrect?

6. What unit do astronomers use to measure distances in the universe?

7. What advantage does the Hipparcos satellite have over Earth-based measurements?

8. Read "Across Canada" on page 392 of the textbook. What did Dr. Sawyer Hogg use to predict the distance of the stars from Earth?

Compare your responses with those in the Appendix on page 66.

The Milky Way Galaxy is the large group of stars that includes the Sun. The next animation has been designed to help you gain an appreciation for the vast scale of the Milky Way Galaxy and the universe. You first see a representation of the Milky Way. Then the animation zooms in on the solar system and, finally, on Earth itself.

Play the *Science 9 Multimedia: Astronomy* CD on your computer. View the title "Our Home in the Milky Way."

Near the top of the screen is an approximate size designed to correspond to the given field of view. Remember that 1 AU is equivalent to the distance between the Sun and the Earth. You can clearly observe the vast differences between the sizes of the Milky Way, the solar system, and the Earth.

The vastness of the Milky Way becomes clear when you see how Earth fits into this galaxy. The Earth and its surface features look so small against the enormous scale of the Milky Way.

When you consider that there are billions of galaxies in the universe, you'll appreciate the immensity of the universe.

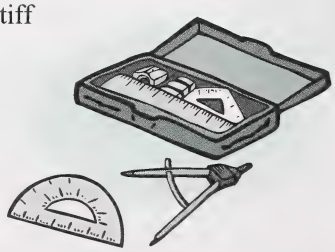
The large distances to stars in the Milky Way and beyond cannot be measured directly. Triangulation is a measurement technique designed to measure distances to remote terrestrial objects indirectly. This technique can also be used to measure distances to stars.

In the following investigation you will use triangulation to determine the distance to an object.

Investigation 5F Using Triangulation to Measure an Unknown Distance

Refer to the "Inquiry Investigation" on pages 390 and 391 of the textbook.

Carry out the steps of "Procedure" by first using a long baseline and then a baseline half as long as the original one. If possible, have your friends, family, or home instructor participate in the activity with you. Measure the distance from your baseline to the object either before or after you do "Procedure." This measured value allows you to check the accuracy of your calculations.



You can create a large protractor on a piece of stiff cardboard. Use a ruler to draw a 60 cm straight line near the edge of the cardboard. Align the baseline of your protractor with this line. Tape it firmly at the centre of the line. Use transparent tape. You need to be able to see the markings on the protractor. Align the lower edge of a ruler with the intersection point between the protractor's baseline and the 90° line. Carefully draw a series of lines outward from this centre every 10°. Mark each of these lines 25 cm above the protractor to create an arc. Join the marks, label the degree lines, and cut out your protractor.

9. **a.** Answer question 2 of "Conclude and Apply."
   b. Answer the questions in "Pause and Reflect" on page 391.

Compare your responses with those in the Appendix on page 67.

end of investigation

10. To test your understanding of the concepts in this lesson, answer questions 2 and 4 from "Topic 4 Review" on page 392 of your textbook.

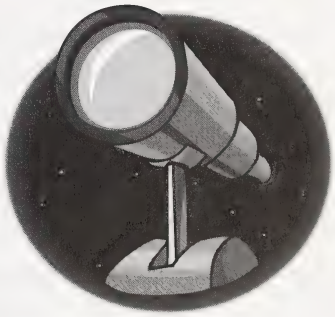
Compare your responses with those in the Appendix on page 67.

Looking Back

The technological improvements in telescopes led to the accumulation of more and better information about our solar system and the universe. In this case the relationship between science and technology serves as an example of scientific knowledge being advanced by enhancements in technology.

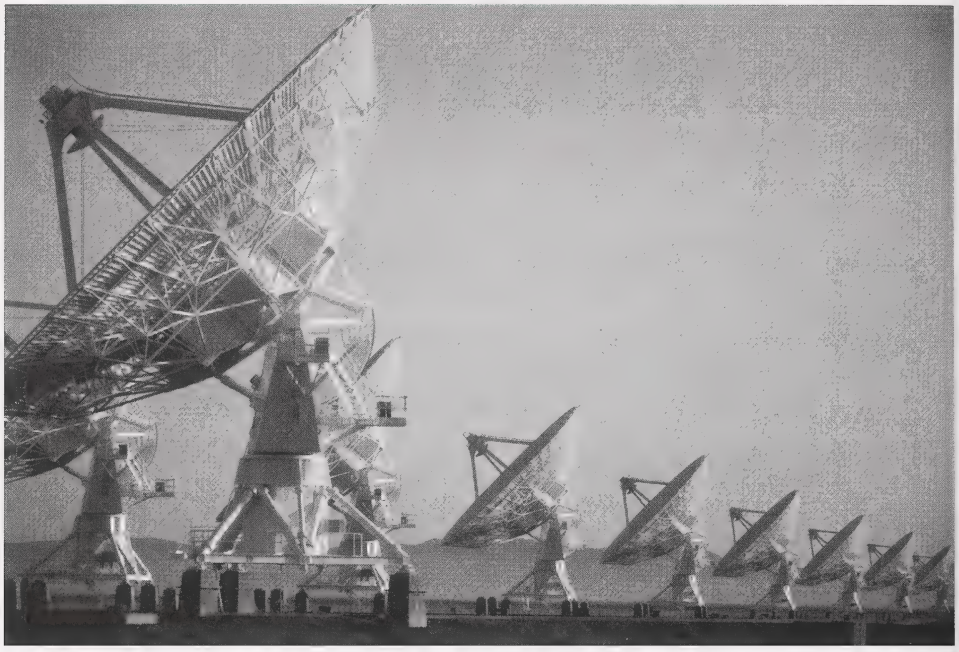
You studied how

- the development of bigger telescopes led to the discovery of the outer planets
- computer technology is used to enhance images
- astronomers measure distance



Turn to Assignment Booklet 5A. Complete questions 4 to 6 from Section 2.

Lesson 3: What Channel Is That?



Have you listened to a radio recently? While you listen to a music show or some other program, the signal your radio decodes is being carried by radio waves. Radio telescopes, like huge TV satellite dishes, have been built to collect radio waves coming from the sky. Radio waves are a form of **electromagnetic radiation**. You may recall that visible light is also a form of electromagnetic radiation. Visible light forms just a small band in the electromagnetic spectrum.

electromagnetic radiation: *varying types of energy waves that are emitted by stars and that travel through space*

You have learned that the visible light from celestial objects carries information about the object itself. So it should not be a great surprise to you that other forms of electromagnetic radiation also tell tales about their sources.

Turn to page 393 of the textbook and read the introductory paragraph of "Topic 5." Study "Figure 5.33."

Have you ever been annoyed by a noisy, crackling sound on your radio? It's due to electrical disturbances that emit irregular radio waves. In the following activity you will produce radio waves such as these. You will detect the waves by using a portable radio set.

Find Out Activity Give Me Some Static!

Refer to the activity on page 393 of the textbook.

Carry out the steps of "Procedure."

1. Answer "What Did You Find Out?" questions 1 to 3.

Compare your responses with those in the Appendix on page 68.

Radio Telescopes

From your study of electrostatics you will recall that a spark is the result of electrons moving between two points. Receiving radio waves from space provides evidence that electric charges move from one point to another in space.

Variations in radio waves give astronomers information about the wave source.

Read pages 394 to 397 in the textbook to learn about the history of radio telescopes and the development of the interpretive techniques used by radio astronomers.

2. Compare the function of radar equipment used in air-traffic control to that used in radio telescopes.

3. What characterizes a bright radio object in space?

4. Describe how radio astronomers "see" by using radio waves.

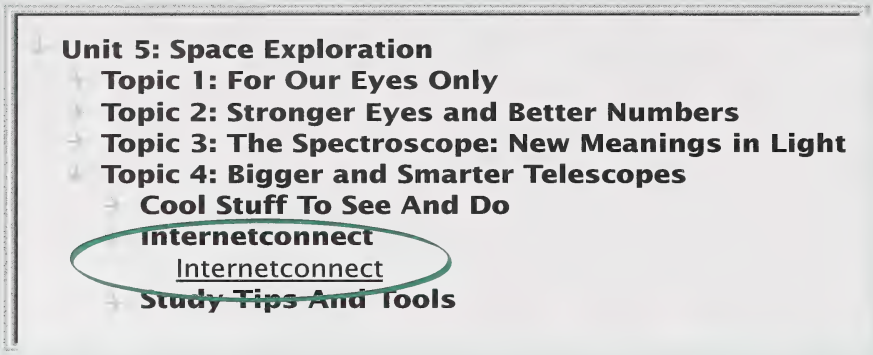
5. How do radio astronomers increase the resolution of radio telescopes?

6. What technique does the Very Long Baseline Interferometry Space Observatory Program use to simulate a single, gigantic radio dish?

Compare your responses with those in the Appendix on page 68.

Going Further

Do some research on the advancements of space telescopes. Follow the "Internet Connect" on page 397 of the textbook. Enter **http://www.mcgrawhill.ca/links/sciencefocus9** into your browser. Once at the target page, click on "continue" or the "INTERNET CONNECT" icon. Then navigate to the circled "Internetconnect" that follows.


Unit 5: Space Exploration
Topic 1: For Our Eyes Only
Topic 2: Stronger Eyes and Better Numbers
Topic 3: The Spectroscope: New Meanings in Light
Topic 4: Bigger and Smarter Telescopes
Cool Stuff To See And Do
Internetconnect
Internetconnect
Study Tips And Tools

7. To test your understanding of the concepts in this lesson, answer questions 1, 2, and 5 from "Topic 5 Review" on page 397 of your textbook.

Compare your responses with those in the Appendix on page 68.

Looking Back

In this lesson you studied the development of radio telescopes and the use of radio waves to explore the universe.

Lesson 4: Wrap-up

To review the concepts covered in this section, turn to page 398 in your textbook and answer questions 1, 3, and 4 from "Wrap-up: Topics 3 to 5."

Check your answers with your teacher or home instructor.

Section 2 Conclusion

NASA/STScI

In this section you investigated the use of advanced technologies to explore space. You examined spectral analysis to determine the composition of stars and the distances to them. You also examined how larger, more versatile light and radio telescopes with computer technology assistance provide a better view of the universe.

The newly installed Advanced Camera for Surveys (ACS) aboard NASA's Hubble Space Telescope is an example of an advanced space-exploration technology.

The image on this page was taken with ACS on April 2, 2002. Until that date, such detailed views of deep space had never been possible. The Cone Nebula is 2500 light-years away from Earth.

Turn to Assignment Booklet 5A. Complete questions 7 and 8 from Section 2.

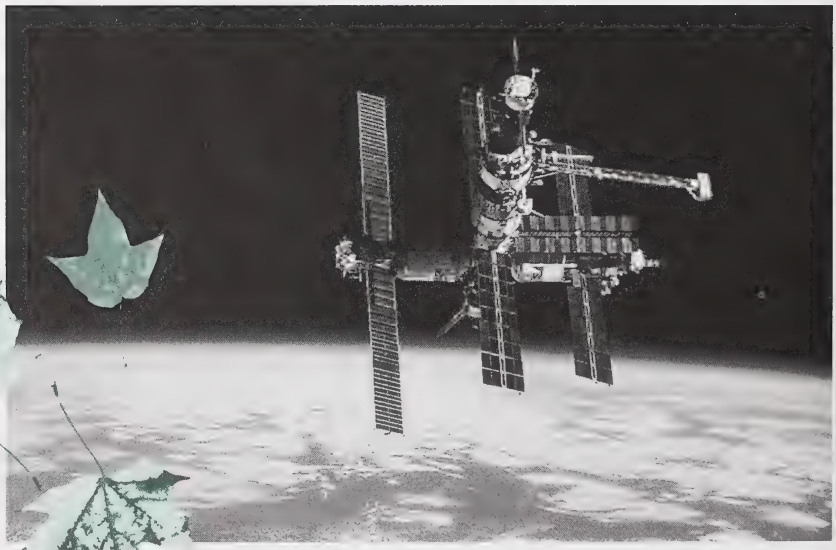
Section 3

Satellites and Spacecraft

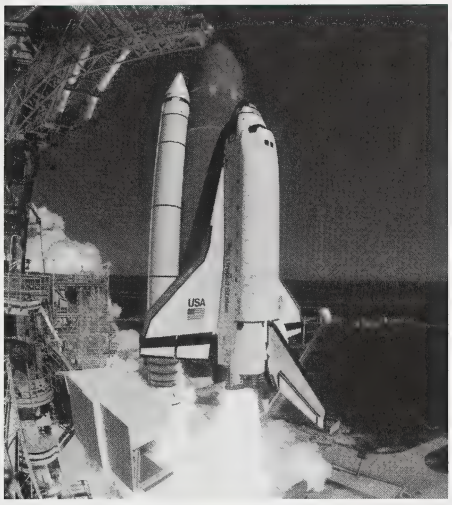
Imagine that your family is going on a vacation. Maybe you enjoyed travelling to a cabin in Jasper National Park for a number of summers. But this time you're going to a new destination—the Okanagan Valley in British Columbia. It's exciting to go somewhere you've never gone before.

How exciting it must have been for those explorers who first went into outer space and for those who first placed their feet on the Moon's surface! These individuals went where no human being had ever gone before! There are now people spending weeks and even months above Earth's atmosphere in the orbiting International Space Station. That must also be sensational! Recent developments in technology have opened the way to such new experiences.

In this section you will examine the technologies used to get into space. These technologies provide closer views of the Moon, the solar system, and the universe. You will also follow the history of human space exploration.



Lesson 1: Above the Atmosphere



Before rockets were developed, only characters in myths and science fiction were able to escape Earth's gravity and move through the universe. Have you read the story of Icarus?

Icarus is a youth from Greek mythology. His father made him wings from wax and feathers. Icarus flew toward the Sun, but when he got too close to it the wax melted and his wings came apart.

Space travel was made real by rocket technology. Today, rocket engines launch space probes, satellites, and humans beyond the confines of Earth's gravity.

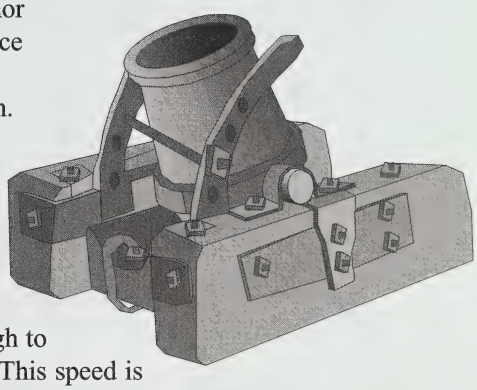
In this lesson you will investigate the history of rockets and their use in launching satellites and spacecraft. You will appreciate the importance of computers in guiding space flight and in processing data received from space.

Also, you will study the contribution of space technologies to improved

- communication
- navigation
- weather forecasting
- astronomy

DID YOU KNOW?

In his 1865 novel *De la Terre à la Lune (From the Earth to the Moon)*, author Jules Verne already envisioned space travel. He describes a giant cannon used to fire a projectile to the Moon.



However, the muzzle velocity of such a cannon would have to be close to 11 km/s. The calculation of this speed ignores the loss of kinetic energy due to air resistance. A launch speed of 11 km/s is enough to completely escape Earth's gravity. This speed is enough to place a spacecraft in orbit around the Earth.

Rockets and Computers

Space exploration and astronomy in the past four decades are closely linked to advances in rocket and computer technology. Today's space shuttles are capable of accomplishing a wide variety of tasks. Computers are used to calculate launch trajectories. Computers are also used to monitor and control satellites and probes once they are in orbit.

Turn to pages 399 and 400 of the textbook and read the introductory paragraph of "Topic 6." Also read "Rockets—Getting Up There" and "Computers—Making Adjustments." Pay attention to the margin features.

1. Explain the scientific principle illustrated by rocket propulsion. Who formulated this principle?

Compare your response with the one in the Appendix on page 69.

The next "Going Further" is rocket science. You can make your own rocket by using a large pop bottle and a bicycle pump.

Be careful! Get approval from your teacher or home instructor before the launch.

Going Further

Refer to "Problem-Solving Investigation 5G: Blast Off!" on page 401 of the textbook. In this investigation you are challenged to design, construct, and launch a simple rocket. If possible, have your friends, family, or home instructor participate in the activity with you. Carefully note the safety precaution. Have fun!

Now turn to page 402 of the textbook and read "Using Gravity." The reading and the diagram describe a slingshot in space. You'll see that the gravity of another planet can be like a slingshot—that's because its gravity can fling a spacecraft ahead along the planet's orbit. As this gravity flings the spacecraft ahead, the spacecraft gains speed!

2. Describe the technique used by scientists to accelerate spacecraft without using fuel.

Study the remainder of the text and diagrams on pages 402 and 403. Find out more about extending human vision with space technologies.

3. What role do charge coupled devices play in astronomical imaging?

4. What is the advantage of placing a telescope in space?

5. Name both a well-known natural satellite of Earth and a prominent artificial satellite.

Compare your responses with those in the Appendix on page 69.

Artificial Satellites

The ability to launch objects into orbit around Earth has led to the use of artificial satellites in communication, navigation, and monitoring. Read pages 403 to 406 in the textbook for details on the use of artificial satellites that circle Earth.

6. Describe how a geosynchronous orbit differs from a low-Earth orbit.

7. List three remote sensing applications.

Photographs taken by orbiting satellites are now commonly used to monitor surface and atmospheric events.

The following activity asks you to analyze satellite photographs.

Find Out Activity Interpreting Satellite Photographs

Refer to the activity on page 406 in your textbook.

Carry out the step of "Procedure."

8. Answer "What Did You Find Out?" questions 1 to 3.

Compare your responses with those in the Appendix on page 69.

Have you ever been lost in a wilderness area or in a large shopping mall? That can be distressing. If only you could get back to where you started from. Using a global positioning system (GPS) unit, you could return to where you were without relying on your own memory.

You simply start walking so that the cursor on the GPS screen returns to the point on the screen that represents your starting point. Of course, you have to watch where you're going to avoid an accident. When the cursor coincides with your starting point, you'll be back at the beginning.

The technology behind a GPS unit is very sophisticated. It involves satellites and computers.

Turn to page 407 of the textbook and read "Global Positioning System (GPS)."

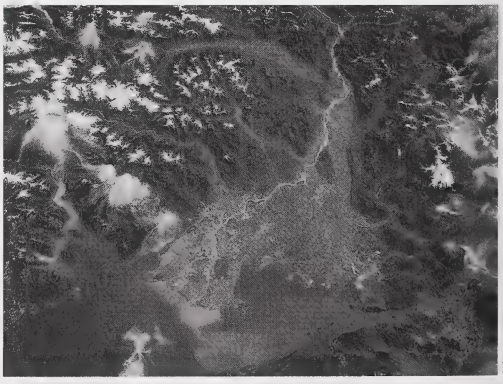
9. Which of the following does a GPS unit use to determine location?

A. blue-shift spectroscopy
B. the Doppler effect
C. red-shift spectroscopy
D. triangulation

Compare your response with the one in the Appendix on page 70.

This photo of Vancouver on the Fraser River delta was taken from space and is available on the Internet. It's from the NASA Space Shuttle Earth Observations Photography database of images.

You can find your own images taken from space. Do the next "Going Further" item to begin a virtual treasure hunt.



[1] Image #STA028-71-16 courtesy of Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center http://eol.jsc.nasa.gov.

Going Further

Refer to "Find Out Activity: Where Are You?" on page 408 in your textbook. Use this activity to guide your research and analysis of satellite views from places on Earth.

10. To test your understanding of the concepts in this lesson, answer questions 1, 2, and 5 of "Topic 6 Review" on page 408 of your textbook.

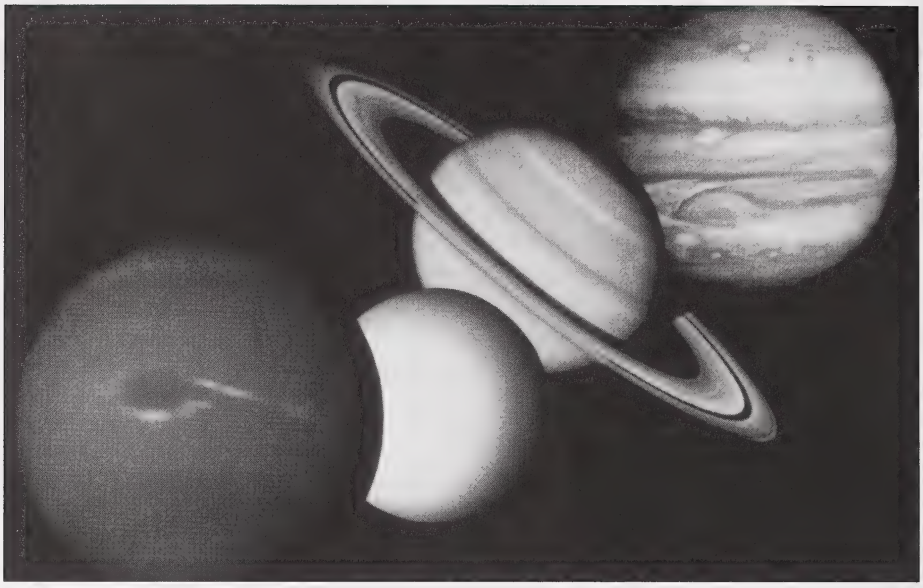
Compare your responses with those in the Appendix on page 70.

Looking Back

In this lesson you followed the development of rockets and their use in launching satellites and spacecraft. You appreciated the role of computers in guiding space flights and in processing data received from space. Also, you studied how space technology has improved communication, navigation and weather forecasting, and astronomy.

Turn to Assignment Booklet 5B. Complete questions 1 to 5 from Section 3.

Lesson 2: The Solar System Up Close



Have you flown in an airplane? From the air, a landscape tends to look flat. Features such as individual trees, houses, and sheds look very small if they are visible at all. The features show no detail. You only really find out what's down there when you're on, or at least close to, Earth's surface.

From a long distance away, celestial objects also show few details. Until recently, even Earth's closest neighbours in the solar system were far enough away to remain mysterious. Advances in rockets and computers have allowed spacecraft to visit Earth's neighbours. These spacecraft have sent data and pictures from up close.

In this lesson you will study space flight and its contribution to knowledge about the solar system.

Turn to page 409 of the textbook and read the introductory paragraph of "Topic 7."

The Sun and Its Satellites

When you hear the weekend weather report, you're probably happy to hear that it's going to be sunny, rather than cloudy. The warmth and light you enjoy from the Sun is a reminder that the Sun is an essential source of light and thermal energy for Earth.

The Sun is also important for its gravitational force. This force keeps the Earth and the rest of the solar system in their places. What may surprise you is that much of what scientists know about the Sun and its satellites has only been acquired since they were able to send space probes into outer space.

Turn to page 409 of the textbook and read "The Sun." Also read the "Did You Know?" items.

Find out more about the make-up of the Sun.

Play the *Science 9 Multimedia: Astronomy* CD on your computer. View "The Interior of the Sun."

1. How is the boundary of the solar system defined?

2. What produces the aurora borealis and the aurora australis?

3. The energy from the Sun is generated by a type of nuclear reaction.

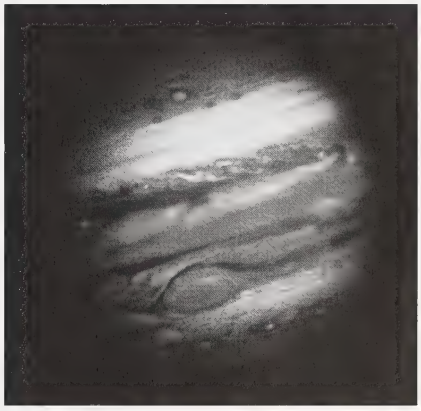
   a. What type of nuclear reaction occurs in the Sun?
   b. What condition is present to promote this type of reaction?

Turn to pages 410, 418, and 419 of the textbook and read "Travelling Through the Solar System," "Exploring the Outer Planets," and "Voyager Today."

4. How does NASA manage to send spacecraft to the outer planets without merely relying on rocket power?

5. Are the following moons of Jupiter—Io, Europa, Ganymede, and Callisto—classified as terrestrial or gaseous?

6. Where are the Voyager spacecraft now?



Compare your responses with those in the Appendix on page 70.

In the following activity you will take a more detailed look at each of the planets by noting their similarities and differences.

Find Out Activity Planetary Profiles

Refer to the activity on page 411 in the textbook. Read the introductory paragraph. Then use the information on the "Data Cards for the Inner Planets" and the "Data Cards for the Outer Plants" on pages 412 to 415 to find the answers to the "What Did You Find Out?" questions. You may want to extend your research by following "Internet Connect."

7. Turn to page 411 of the textbook and answer "What Did You Find Out?" questions 1 to 7.

Compare your responses with those in the Appendix on page 71.

One of the goals set for NASA is the human exploration of Mars. It will be several decades before people travel to Mars—but it will likely occur in your lifetime.

Play the CD titled *Science 9 Multimedia: Astronomy* on a computer. Once the first screen appears on the computer, select "A Renewed Spirit of Discovery." This video segment shows you a futuristic vision for humans in space.

The voyage will be challenging. Although spacecraft travel at tremendous speeds—compared to speeds on Earth—spacecraft will still need a whole year to reach Mars. Because a Mars visit involves a round trip, the visit will take at least two years.

A spacecraft to Mars must have a self-contained ecosystem to support life for an extended period. Having plants on board can help because they remove carbon dioxide from the air and supply oxygen.

Astronauts will also need living quarters on Mars itself. In the next investigation you are challenged to design some living spaces.

Read the introductory paragraph of the "Inquiry Investigation" on page 416 of the textbook.

Investigation 5I Mars Colony

Refer to the "Problem-Solving Investigation" on page 417 in your textbook.

Read the introductory paragraph and "Challenge."

8. In the process of solving a technological problem, evaluation is an important step.

a. List things to consider when designing a Mars habitat.

b. Complete questions 2 and 3 from "Evaluate."

Compare your responses with those in the Appendix on page 71.

end of investigation

In the next "Going Further" you can do more extensive planning for a Mars colony. You can also—in a sense—carry out your plan by making a poster, a model, or another form of communication to represent your Mars habitat.

Going Further

Revisit "Problem-Solving Investigation 5I: Mars Colony." Focus on "Plan and Construct."

Follow the "Internet Connect" for spectacular information about the surface of Mars. This information has a bearing on your habitat.

9. To test your understanding of the concepts in this lesson, answer questions 3 and 5 of "Topic 7 Review" on page 419 of your textbook.

Compare your responses with those in the Appendix on page 72.

Looking Back

In this lesson you examined how advances in space technology have contributed to scientific knowledge about the solar system.

Turn to Assignment Booklet 5B. Complete questions 6 to 8 from Section 3.

Lesson 3: People in Space

Have you ever taken part in or seen others compete in a sporting event? It's often in a track meet where you have your personal best in the 100 metres, the high jump, or another event. It seems that competition can bring out the best in the participants.

A great deal of the impetus for people going into outer space involved competition—the desire to defeat an opponent. This competition spurred on the race to get into space and to the Moon.

Turn to page 420 of the textbook and read the introductory paragraph of "Topic 8."

Going Beyond the Atmosphere

You can probably remember a time when you walked up several flights of stairs because an elevator was out of commission. That's tiring, especially when you try to walk too fast. It takes lots of your energy. Imagine a spiral staircase going up to 200 km—about the height where a satellite can orbit with almost no aerodynamic drag. Just getting to that height takes a huge amount of energy.

But at the height of the orbit, you don't have a staircase to support you. In order to stay up there you need to be moving at a speed of about 29 000 km/h. That speed allows you to stay in an orbit around Earth. Getting to that speed also takes an enormous amount of energy.

Turn to pages 420 and 421 of the textbook. Read "Breaking Free of Earth's Gravity."

Why does something stay in orbit way up there? The next "Going Further" answers this question in an elementary but effective manner.

Going Further

To find out how a body can orbit Earth, go to the following site:

http://spaceplace.nasa.gov/en/kids/orbits1.shtml

You'll also find out why astronauts feel weightless, even though Earth's gravity does extend into space.

1. Who was the first person in space? Who was the first person from the United States in space?

Turn to page 421 of the textbook and read "The Apollo Program."

2. How did the Apollo program differ from Project Mercury?

Compare your responses with those in the Appendix on page 72.

Having a human being inside a space capsule places extra demands on the design of the capsule. In the following investigation you will design a container. The container must withstand the physical stress of both a launch and a landing, while carrying a raw egg inside. In designing your container you will face similar challenges to those people who designed space capsules!

Investigation 5J Design a Space Capsule

Refer to the "Problem-Solving Investigation" on page 422 of your textbook.

You can use someone's arm (and hand) as a launcher. Use a shot-put type of push to launch the capsule.

If possible, have your friends, family, or home instructor participate in the activity with you. You can plan, build, and test co-operatively or competitively.

Continue with the following only with the approval of your home instructor or teacher.

Carry out the steps of "Plan and Construct." Your home instructor will help identify any safety concerns.

3. Answer questions 1 to 3 of "Evaluate" and questions 4 and 5 of "Extend Your Skills."

Compare your responses with those in the Appendix on page 72.

end of investigation

After years of competition, the Soviet Union and the United States decided to work in a more co-operative manner. A space rendezvous would demonstrate a new friendship.

When these two countries developed space vehicles, they went through the process of technological problem-solving on their own. They tackled problems in differing, yet effective ways. For example, both countries had to provide an artificial atmosphere for the occupants of their space vehicles. Each of the competitors came to a different solution. A rendezvous in space had to accommodate the differing cabin atmospheres in the Apollo and Soyuz spaceships. You will soon read about how this took place.

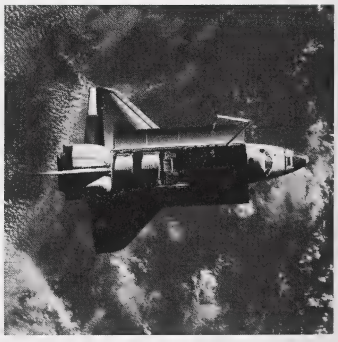
Turn to page 423 of the textbook and read "Meeting in Space."

4. What was one of the major challenges to the Apollo/Soyuz linking mission?

5. Describe the effect of microgravity on the human body.

Compare your responses with those in the Appendix on page 73.

The Apollo/Soyuz test project was the first human space flight jointly managed by the two former space rivals. This was the first of many co-operative ventures involving both the space shuttle and the International Space Station. Space projects became more international as more countries took on supporting roles.



Turn to pages 424 to 426 of the textbook and read "The Space Shuttle" and "The International Space Station." Include the "Did You Know?" margin features.

6. What is the advantage of the space shuttle over previous space capsules?

7. List the technological contributions Canada makes to the space program.

8. What are the anticipated benefits of the International Space Station?

9. Who are the major partners in the International Space Station project?

Compare your responses with those in the Appendix on page 73.

DID YOU KNOW?

Astronaut Roberta Bondar was the first Canadian woman to go into space. In early 1992, Dr. Bondar flew into space on the space shuttle *Discovery*. On this mission, Dr. Bondar performed scientific experiments designed for the microgravity environment of space flight. You can find out more about Dr. Bondar at the following site:

http://collections.ic.gc.ca/science/english/bio/bondar.html

In 1999, Julie Payette became the second Canadian woman to go into space and the first Canadian to board the International Space Station. Julie also went into space on the shuttle *Discovery*. As a mission specialist, her primary responsibility was the performance of scientific tasks. During this mission she also operated the Canadarm robotic arm. For more about Astronaut Payette you can go to

http://www.space.gc.ca/asc/eng/csa_sectors/human_pre/cao/biopayette.asp

Do the next "Going Further" to find out about the first space stations.

Going Further

Follow the "Internet Connect" on page 426 of the textbook. It will guide you along the history of space stations. Click on "continue" and navigate to the appropriate "Internetconnect."

In "Investigation 5J: Design a Space Capsule," a raw egg that took the place of an astronaut required protection from jarring and heat. Having a real astronaut places even more demands on spacecraft. That leads to these questions. Isn't it better to have spacecraft without people inside? Can't data be collected through remote manipulation and remote sensing?

The following investigation challenges you to think about the type of space mission that has people on board versus the type that doesn't. You'll consider the advantages and disadvantages of each type of mission.

Refer to the "Decision-Making Investigation" on page 427 of your textbook.

Read "Think About It," "How Can Science Help?" and "Resolution."

10. State your position on this resolution and provide four statements you would use to defend it.

Compare your response with the one in the Appendix on page 74.

end of investigation

Space missions involve a great deal of technological problem solving. In the next "Going Further" you will develop a space-related technological device.

Going Further

Complete "An Arm of Your Own." You will find this project on pages 432 and 433 of the textbook.

11. To test your understanding of the concepts in this lesson, answer questions 1 to 4 and question 7 from "Topic 8 Review" on page 428 of your textbook.

Compare your responses with those in the Appendix on page 74.

Looking Back

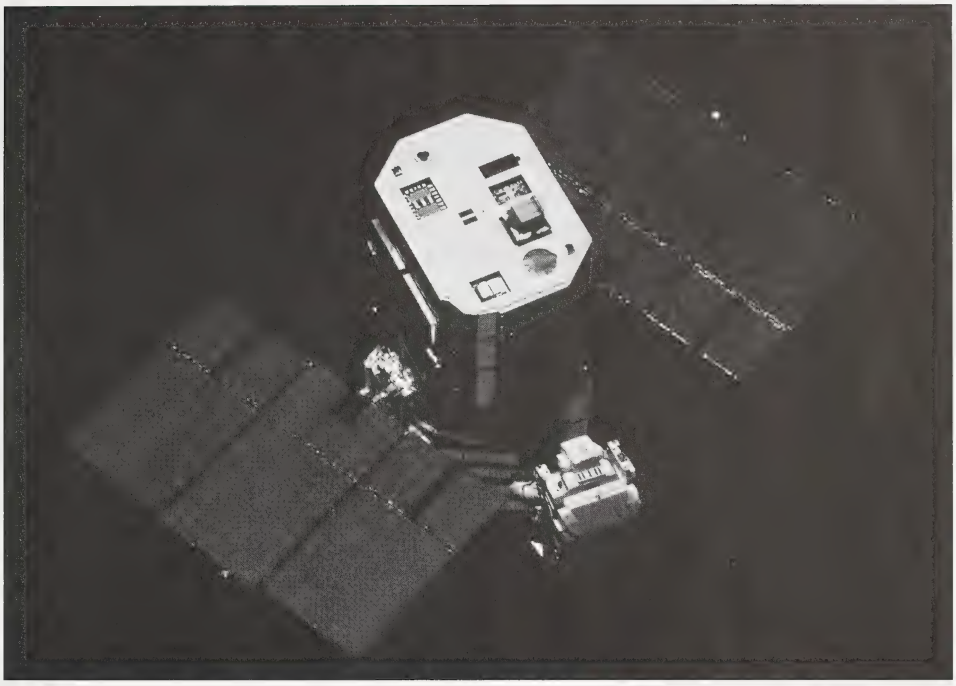
In this lesson you studied the history of space travel by humans. You also identified issues that influenced the development of the various space programs.

Lesson 4: Wrap-up

To review the concepts covered in this section, turn to page 429 in your textbook and answer questions 1, 5, 7, and 8 from "Wrap-up: Topics 6 to 8."

Check your answers with your teacher or home instructor.

Section 3 Conclusion



In this section you examined the technologies used to get into space. You saw closer and better views of the Moon, the solar system, and the universe made possible by moving beyond Earth's atmosphere and into space. You studied the historical events of space exploration and considered the future direction of human activity in space.

Satellites above Earth are just part of the fleet of space technology that humans use to probe Earth's neighbourhood.

The desire for a better understanding of the nature of the solar system and the universe has led to a chain of scientific and technological developments. These developments have given humans the capacity to escape Earth and study outer space.

Turn to Assignment Booklet 5B. Complete questions 9 to 12 from Section 3.

Module Summary

In this module you studied the growth of astronomy. This field of science started with observations using the naked eye. Today, the exploration of space is done with the use of the entire electromagnetic spectrum. Spacecraft are used to gather data about the universe. You examined how the ability to "see" farther and better has improved people's understanding of the solar system and the universe. You also considered the use of astronauts in space exploration and their contribution to new technology in space and on Earth.

When you look up at the night sky you may still have the question, "What's really up there in space?" New technologies have played an essential role in unveiling some of the mystery. Yet, there is much more to learn and still much to wonder about.

Module Review

To review the concepts covered in this module, turn to page 434 in your textbook and review the concepts listed under "Unit at a Glance." To help test your understanding of the concepts covered in this module, answer questions 1, 2, 5, 8, 13, 18, 20, 26, and 28 on pages 435 to 437.

Check your answers with your teacher or home instructor.

Turn to Assignment Booklet 5B. Complete the Final Module Assignment.

Appendix

Glossary

Suggested Answers

Image Credits

Glossary

adaptive optics: the technology that corrects for the effects of atmospheric conditions on the image of a telescope in real time

altitude-azimuth co-ordinates: co-ordinates that describe the location of a celestial object relative to a fixed Earth

The altitude co-ordinate is the angle above the horizon, and the azimuth co-ordinate is the horizontal angle measured clockwise from north.

astrolabe: an instrument designed to observe the positions and measure the altitudes of celestial bodies

astrology: the study of the supposed influence of the stars on human concerns; a pseudoscience based on belief, not evidence

astronomical unit: a measure of distance within the solar system equal to the average distance between Earth and the Sun

astronomy: the scientific study of the universe and its content

ballistic missile: a weapon which, after being initially self-powered and guided, follows an unpowered trajectory, controlled only by gravity and air resistance

blue shift: the displacement of spectral lines of a celestial object toward the blue, shorter wavelengths of the spectrum

This indicates the motion of the object is toward the observer.

charged coupled device: a device that changes light signals into electric signals in digital format

constellation: any one of the star groups interpreted as forming an outline in the sky

convex lens: a lens that is thicker in the middle than around the edges

cosmonaut: a Russian astronaut

Doppler effect: the change in observed frequency of a sound and electromagnetic wave due to relative motion of the source and observer

Earth-centred model: a model of the universe that places Earth at the centre, with the Sun, Moon, and planets revolving around it

electromagnetic radiation: varying types of energy waves that are emitted by stars and that travel through space

ellipse: a regular oval for which the sum of the distances of any point on its perimeter from either of two points—the foci—within it is constant

escape velocity: the minimum speed an object must acquire to permanently escape from the gravitational attraction of Earth

exhaust velocity: the velocity of gaseous particles or other particles in the exhaust stream of the nozzle of a rocket engine

frame of reference: a set of axes or a co-ordinate system for the purpose of assigning position and time to events

geocentric: centred on the Earth

geosynchronous: orbiting over a fixed point on Earth and in rhythm with it

global positioning system: a navigation system designed to use 18 to 24 satellites, each carrying atomic clocks, to provide a receiver anywhere on Earth with precise accuracy its three-dimensional position, velocity, and time

gravitational assist: a technique using the gravity of a planet to accelerate a spacecraft and change its direction

heliocentric: centred on the Sun

light-year: a unit of measurement of astronomical distance

It's the distance light travels in one year.

low-Earth orbit: a satellite orbit between 200 and 800 km above Earth's surface

microgravity: the term used to describe the effect of constantly free falling on objects in orbit around Earth

newton (N): the SI unit of force (weight)

parallax: the apparent shift or the difference in apparent direction of an object as seen from two different points

This term is especially used to refer to the angular difference in direction of a celestial body as measured from two points on Earth's orbit.

payload: the material or devices that a rocket carries as a load

planet: a relatively small celestial body circling around a star—in particular the Sun and its nine planets

radio astronomy: the study of celestial objects by the measurement and analysis of their emitted electromagnetic radiation in the radio wavelengths range (approximately 1 mm to 30 mm)

red shift: the displacement of spectral lines of a celestial object toward the red end of the spectrum

Such a shift indicates the object is moving away from the observer. The greater the red shift, the greater the speed of the object.

reflecting telescope: a telescope using a mirror for the objective

refracting telescope: a telescope using a lens for the objective

remote sensing: the gathering and recording of information without actual contact with the object or area being investigated

resolving power: a quantitative measurement of a telescope's ability to produce fine detail of an object in view

solar wind: the supersonic flow of gas, composed of ionized hydrogen and helium, which continuously flows from the Sun out through the solar system

spectroscope: an optical instrument consisting of a slit, a collimator lens, prism or grating, and a telescope or objective lens that produces a spectrum for visual observation

spectrum: a series of colours formed when a beam of light is separated (as by refraction or diffraction) so that its component wavelengths are arranged in order

staged rocket: a rocket with more than one stage; a self-propelled separable element

telescope: a device used to magnify objects at great distances

triangulation: a method of measuring distance by constructing an imaginary triangle between an observer and an object whose distance is to be estimated

This is also known as the parallax technique.

very long baseline interferometry: a method of improving the resolution in the observation of radio sources

The sources are simultaneously observed by two radio telescopes which are very far apart, and their signals are combined electronically or on computers.

Suggested Answers

Section 1: Lesson 1

1. The two frames of reference are on the ground and on the moving bus.

Note: With your life experience, these two frames of reference are normal. You can automatically relate one frame to the other. The use of other frames of reference can be quite complex. For example, if you were standing on the Moon, all other celestial bodies (stars, planets, or the Sun) would appear to revolve around the Moon.

2. As Earth moves in its orbit around the Sun, a given star rises and sets four minutes earlier each day than it does the day before. As the Earth's position in relation to the stars changes, different stars become visible in the night sky.

Note: Remember that the stars are always present—you can't see them during the day because they blend in with the light from the Sun and the sky.

3. The Moon and the Sun rise and set at different rates than the stars do.

4. They are the only planets visible without the use of binoculars or telescopes.

Note: Light travels huge distances to get to Earth. Interference blocks or reroutes some of the light. As a result, stars twinkle. Planets don't twinkle due to their relatively short distances to Earth. Light reflecting off the planets runs into little interference, so you receive a fairly steady image of the planets.

5. a. The co-ordinates used to fix an object relative to Earth are the azimuth—the angle measured clockwise from north, and the altitude—the angle above the horizon.

b. You are using the stars as your frame of reference.

Note: To use the stars as a reference frame to fix an object, the object's position has to be observed relative to a given set of stars on several nights. Over a period of time, the object's motion relative to the stars can be noted.

6. **Textbook questions 1 to 3 from "Practice Problems," page 359:**

   1. Star A is the correct answer.

   2. The correct answer is E.

   3. Star C is the star that fits the co-ordinates.

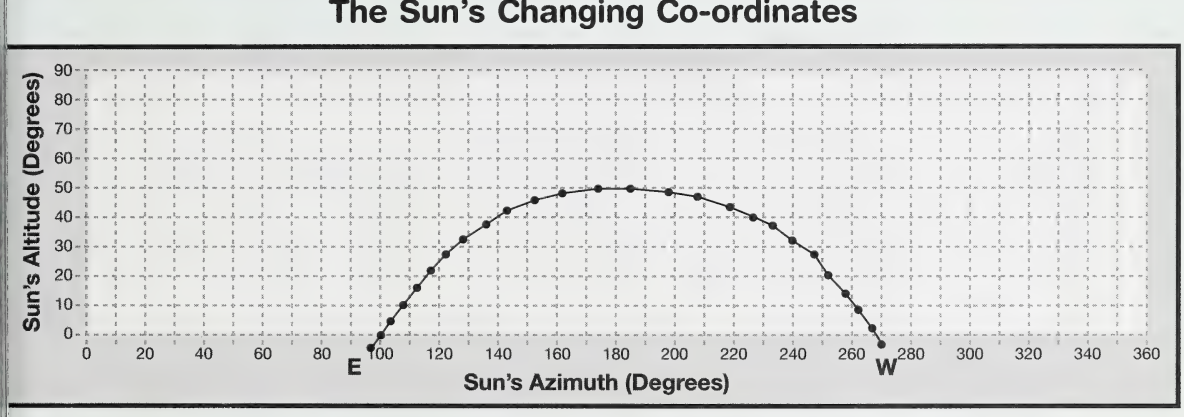
7. **Textbook questions 1 and 2 of "Analyze," page 361:**

   1. The azimuth is divided into 360°, and the altitude into 90°.

   2. It doesn't matter which co-ordinate you set first. Up and over gives you the same information as over and up.

8. **Textbook questions 1 to 4 of "Analyze," page 362:**

   1. The graph should look similar to the following one. The actual curve will depend on the time of year and day that observations were made.



   2. The highest altitude depends on the time of year. It will range from 14° to 60°.

   3. The time is location dependent but in Alberta it should be about 12:30 PM MST or 1:30 PM MDT.

   4. The part holding the straw functions like an astrolabe.

9. Aristotle's model of the universe was an Earth-centered model. It consisted of many spheres. These were

   - Earth
   - air
   - the Moon
   - five planets
   - water
   - fire
   - the Sun
   - the celestial sphere containing the stars on the outside

   All the inner spheres above water were "crystalline" or transparent because the stars could be seen through them.

   Note: Aristotle's model required 55 different spheres to account for all the motions observed—that's not very elegant. Yet, this model allowed humans to predict the dates and times when celestial bodies rose and set. A scientific model does not have to be "perfect" to be useful.

10. Ptolemy introduced epicycles to explain the retrograde motion of Mars, Jupiter, and Saturn. This solved one of Aristotle's problems but made the model even more complex.

    Note: Retrograde motion is a perceived change in a planet's direction of motion due to the changing position of the observer's frame of reference—the Earth.

11. Copernicus proposed the heliocentric model. It placed the Sun at the centre of the universe and the planets, including Earth, in circular orbits around it. In this model, day and night is caused by Earth rotating on its axis.

    Note that in *heliocentric*, *helio* means Sun. In *geocentric* (think of *geology* and *geometry*), *geo* means Earth.

12. Some people had thoughts such as these.

    A rotating Earth will fling people off. There should be a constant fast east wind. Earth not being the centre of the universe meant lowering the status of humans who believed, at the time, that they were the most important beings in the universe.

13. **Textbook questions 1 to 4 and question 6 of "Topic 1 Review," page 365:**

    1. A frame of reference is a set of axes or a point from which motion and position are measured.

    2. Earth was their frame of reference. The apparent motion of the celestial objects gave them the impression that Earth was at the centre of the universe.

    3. An astrolabe is an instrument that measures the altitude of an object in the sky.

    4. The first angle is the azimuth, and the second angle is the altitude.

    6. The heliocentric model places the Sun at the centre, with Earth and the planets in orbit around it. Meanwhile, the geocentric model is Earth-centred.

Section 1: Lesson 2

1. A Dutch optician named Hans Lippershey invented the telescope.

2. A simple telescope is made of two convex lenses. The *objective* lens is at the front of the telescope and the *ocular* lens is near the eye of the user.

3. **Textbook question 1 in "Pause and Reflect," page 367:**

    1. Galileo observed four moons orbiting Jupiter rather than Earth.

        Note: By early 2003, astronomers had spotted 38 moons orbiting Jupiter.

4. From the changing shadows on the Moon, Galileo inferred that it has mountains and valleys similar to those on Earth.

5. A refracting telescope uses only lenses. A reflecting telescope uses a mirror as the objective.

6. The diameter of the objective of a telescope determines its resolving power, which is the amount of detail seen in the image.

7. Kepler used elliptical (oval) orbits in his model. Kepler used Tycho Brahe's data to improve upon the Copernican model. Brahe's data required that the planets follow an elliptical orbit.

8. Newton's law of universal gravitation states that there exists a force of attraction between all masses in the universe. The Sun's gravitational force pulls the planets toward it. Without this force the planets would move off in a straight line due to their motion. The combined effect of the planet's orbital speed and the gravitational pull results in an elliptical path.

9. **Textbook questions 1 and 2 of "What Did You Find Out?" on page 371:**

    1. The ellipse looks long and narrow when the pins are far apart. When the pins are close together, the ellipse becomes almost as wide as it is long—it's closer to a circle than an oval.

    2. With the pins almost touching, the ellipse comes close to being a circle.

10. **Textbook question 2 of "Evaluate," page 373:**

    2. Carefully prepared drawings will be more precise than if you used existing objects for the model. Large-scale models which are carefully measured and marked on a sidewalk or road can show relative distances very well. Adding disks of paper cut to scale provides a good indication of the relative sizes of the planets.

11. **Textbook questions 1, 2, 6, and 7 of "Topic 2 Review," page 374:**

    1. Galileo saw four objects moving back and forth across Jupiter.

    2. He observed sunspots move across the Sun's surface, disappear on one side of it, and reappear on the other side.

    6. Tycho Brahe's observations were of a very high precision. To match Brahe's observations a model with the Sun at the centre and elliptical planetary orbits, instead of circular orbits, had to be adopted. This meant the Copernican model needed to be revised.

    7. As Newton's law of universal gravitation explains, there is a force of gravity pulling the planets toward the Sun. This pull combines with the forward motion of the planets to keep them in an elliptical orbit.

       Note: This is similar to an object on a string being twirled around in a circle. The combination of the string pulling the object toward the centre, as well as the object's forward motion, keeps the object moving in a circle.

Section 1: Lesson 3

Check your answers with your teacher or home instructor.

Section 2: Lesson 1

1. Isaac Newton was the first person to demonstrate that white light is really a combination of all the colours. He did this by refracting a beam of sunlight through a prism.

2. Emission or bright line spectra are produced by hot gases at low pressure.

   Hot solids, liquids, and gases at high pressure produce continuous spectra.

   Absorption or dark line spectra are the result of light, produced by a continuous spectra source, passing through a cooler gas.

3. The Sun emits a continuous spectrum. The von Fraunhofer lines indicate the presence of cooler gases near the surface of the Sun. These dark lines indicate the presence of specific elements in the Sun's atmosphere.

4. Gustav Kirchoff and Robert Bunsen investigated the spectra of elements. Their studies established that each element has a unique spectrum that identifies it.

5. A diffraction grating shows more detail in the spectra of light sources than a prism does.

6. **Textbook questions 1 to 4 of "Analyze" and "Conclude and Apply," page 379:**

   1. Incandescent lamps (hot solid filament), the Sun, and fluorescent tubes show continuous spectra. While it is doubtful that you will notice them, there are emission lines of mercury superposed on the continuous spectrum of fluorescent lights.

      Neon advertising signs will show emission spectra because of the gases at low pressure. So will mercury vapour and low-pressure sodium lamps used for streetlights.

   2. Answers will vary depending on the light sources. Note the following:

      - Incandescent lights use hot tungsten filaments.
      - Fluorescent tubes use mercury vapour combined with a special coating on the inside of the tube. This coating converts energy emitted by the mercury vapour to visible light.
      - Neon tubes use neon to produce an orange-red colour.
      - Fluorescent tubes used in advertising signs and decoration use a variety of gases, coatings, and glass colours to produce a variety of colours.

   3. The prediction for incandescent lights should be correct. For fluorescent lights, most students will not have sufficient prior knowledge to make a correct prediction.

   4. Full-spectrum lights provide light which is similar to sunlight. Adding specific gases and coatings to the tubes causes all the colours of "the spectrum" to be produced.

7. Astronomers use spectra of starlight to infer the presence of an element on a star. The position of dark lines in such spectra indicates which elements are present in the star that is the source of the starlight.

8. **Textbook questions 1 to 6 of "Analyze," page 381:**

   1. This simplified representation of the Sun's spectrum shows the absorption lines for hydrogen, sodium, and helium.

   2. Stars 1 and 3 contain calcium.

   3. Star 3 contains sodium.

   4. Star 3 contains mercury.

   5. Star 3 is least like the Sun because star 3 contains mercury.

   6. Comparing the line spectra of stars to the known line spectra of the elements allows astronomers to infer the presence of specific elements in stars.

9. **a.** Astronomers use the Doppler effect to determine the motion of a star. Known spectral lines are red shifted and appear to move toward the red end of the spectrum if the star is moving away from Earth. Spectral lines are blue shifted when the star is moving toward Earth.

   b. Yes, the amount of the shift provides an indication of the motion's speed.

10. **a.** Stellar distances for nearby stars can be measured using parallax. As the Earth goes from one side of its orbit to the other, the closer stars seem to move relative to the more distant ones. The closer the star is to Earth, the greater the apparent shift in its position. Scientists use this apparent shift in position to calculate the distance to the star from Earth. You will learn how to use the parallax technique in the next lesson.

    Note: The red shift indicates more than how a star is moving. It also indicates how far away the star is! In 1929, astronomer Edwin Powell Hubble first reported the relationship between the degree of red shift and distance. According to Hubble's law, the greater the red shift of light emanating from a celestial object, the greater the distance of the object from Earth.

    b. Parallax is the apparent shift or the difference in apparent direction of an object as seen from two different points. Parallax is often used to mean the angular difference in direction of a celestial body as measured from two points on Earth's orbit.

11. **Textbook questions 1 to 4 of "Topic 3 Review," page 384:**

    1. A narrow beam of light is passed through a prism or diffraction grating and is separated into its different wavelengths.

    2. A hot solid produces a continuous spectrum.

    3. The absorption spectrum of the Sun is compared to the known line spectra of elements. If the absorption lines match an element's spectral lines, the element is present.

    4. A star's light being red shifted indicates that the star is receding from Earth.

Section 2: Lesson 2

1. Gerald Kuiper probably used spectroscopy to identify methane on Titan.

2. Linking two telescopes by computer increases the resolving power of the telescopes. The distance between them increases their effective size.

3. Adaptive optics is a technology that constantly "adapts" the mirrors of the telescope to atmospheric conditions. This technology helps to eliminate the "twinkling effect" due to atmospheric refraction.

4. To measure a distance by triangulation, a base line and the angles from the ends of the base line to the object need to be measured.

5. He incorrectly assumed that both stars—Sirius and the Sun—are equally bright.

6. Astronomical distances beyond the solar system are measured in light-years, which is the distance light travels in one year.

7. The Hipparcos satellite increases the baseline for parallax measurements.

8. She used the changing level of brightness in variable stars within globular clusters.

9. **a. Textbook question 2 of "Conclude and Apply," page 391:**

   A longer baseline allows for a more accurate answer. The longest Earthly baseline would be Earth's diameter. You and someone located directly across the globe from you could measure the angle to the Moon at the same time. You could then jointly figure out the distance from the Earth to the Moon.

   b. Textbook questions from "Pause and Reflect," page 391:

   A longer baseline produces a larger difference in angle to the target and, therefore, a more accurate distance calculation. For distant stars, the angle difference (parallax) is too small to detect with the Earth's longest baseline (its diameter).

10. **Textbook questions 2 and 4 of "Topic 4 Review," page 392:**

    2. Astronomers measure the parallax shift relative to more distant stars.

    4. The following is a solution based on the GRASP format.

Given

$d = 4.3$ ly (light-years)

$v = 300\ 000$ km/s

Required

Distance in km

Analysis

Convert 1 ly to km.

Solution

$$d = 4.3\left(300\ 000 \text{ km/s} \times 1 \text{ a} \times \frac{365 \text{ d}}{1 \text{ a}} \times \frac{24 \text{ h}}{1 \text{ d}} \times \frac{60 \text{ min}}{1 \text{ h}} \times \frac{60 \text{ s}}{1 \text{ min}}\right)$$

$d = 4.07 \times 10^{13}$ km

Paraphrase

Proxima Centauri is about 4.07×10^{13} km from Earth.

Section 2: Lesson 3

1. **Textbook questions 1 to 3 from "What Did You Find Out?" on page 393:**

    1. Small, static sparks are usually heard on AM radio, but not on FM radio.

    2. Lightning produces radio waves that are heard as noise or, on TV screens, seen as "snow" or distortions because they carry no decipherable information.

    3. Any device with an electric motor—such as an electric drill, vacuum cleaner, or hair dryer—might make electric shocks. These devices can interfere with radio and television reception.

        Note: This type of interference was very common 15 or more years ago. Modern radios and televisions have much better protection against interference.

2. Radar equipment used in air-traffic control sends signals out and receives reflected signals back. Radio telescopes only receive signals emitted from distant objects.

3. An object that emits a lot of radio signals is considered a bright object. The amount of radio signals emitted is proportional to the energy sent out by the object.

4. Radio astronomers record the strength of the signals and plot them by using computers. The computers can then convert this data into an image by using colours to indicate the signal strength.

5. Increasing the diameter of the receiving dish increases the resolution of the radio telescope.

    Note: This is similar to increasing the diameter of the objective in light telescopes.

6. A radio dish in orbit around Earth in conjunction with a group of ground-based telescopes is used to simulate a single, gigantic dish.

7. **Textbook questions 1, 2, and 5 from "Topic 5 Review," page 397:**

    1. Karl Jansky noted that the source of the radio signal rose and set with other celestial objects.

    2. Radio waves have much longer wavelengths than visible light. Resolution is worse with longer wavelengths. A larger telescope compensates for the poorer resolution provided by radio waves.

    5. Radio waves penetrate rain or clouds, so weather is not a factor when a location is being chosen. The choice would be based on other factors than the amount of rain or sunshine.

        Note: Only optical telescopes need clear skies. Optical telescopes depend on visible light, which is obstructed by rain or clouds.

Section 2: Lesson 4

Check your answers with your teacher or home instructor.

Section 3: Lesson 1

1. Rocket propulsion is an application of the action/reaction principle formulated by Isaac Newton. Newton's third law of motion states that for every action there is an equal and opposite reaction.

2. A planet's force of gravity can be used to slingshot a spacecraft—this accelerates the ship without using fuel. The technique of bringing the spacecraft into a planet's gravitational field is used to change the direction and speed of the craft.

3. Charge coupled devices—instead of photographic plates—are used to record images. These devices convert light signals into digital signals that computers use to process the data.

4. Above Earth's atmosphere the atmosphere can neither block nor distort the radiation it receives.

5. The Moon is a natural satellite of Earth. The Hubble telescope is an artificial satellite.

6. A geosynchronous orbit must be above the equator and at an altitude of approximately 36 000 km above Earth. A satellite in geosynchronous orbit has a period of 24 hours, which is the same as Earth's period of rotation. As a result, a satellite in this orbit is geostationary—this means it remains above the same place on Earth's surface.

   Low-Earth orbits are only 200 to 800 km above Earth's surface. A satellite in low-Earth orbit has a period of about 90 minutes (1.5 h). To an observer on the ground, satellites in low-Earth orbits appear to move very quickly across the sky. In other words, such satellites are not geostationary. Low-Earth orbits (like any non-geosynchronous orbits) need not be above Earth's equator.

   Note: A geostationary orbit is stationary with respect to a frame of reference you are familiar with—the Earth itself. That's why *geo* is in the term.

7. Applications of remote sensing include the following:

   - tracking erosion
   - monitoring clear-cut and burned forests
   - monitoring vegetation
   - checking water pollution
   - monitoring the snow pack
   - checking tectonic activity
   - tracking weather systems
   - monitoring dust clouds caused by volcanic eruptions

8. **Textbook questions 1 to 3 of "What Did You Find Out?" on page 406:**

   1. Photograph A was taken from a geosynchronous orbit. The field of view (area covered) is much larger than B—this means A is positioned at a higher altitude. On close examination, the first horizontal line is labelled 10° North, so the satellite has to be over the equator.

2. The geosynchronous view provides a continuous picture of events as they evolve in one area. In this case, it can help track the path of the hurricanes. The lower satellite's image provides more details about the events.

3. Wind speed and the storm's severity can be estimated, and the movement can be predicted. This allows a storm warning to go out to people in its path.

9. D is the correct alternative.

10. **Textbook questions 1, 2, and 5 from "Topic 6 Review," page 408:**

    1. Liquid fuel has a higher exhaust speed than solid fuel, and liquid fuel weighs less.

    2. A two-stage rocket drops a spent fuel tank and carries on with the rest of the ship.

    5. Remote sensing refers to the technique of taking measurements from afar. These measurements are made without a physical connection.

Section 3: Lesson 2

1. The reach of the solar wind defines the boundary of the solar system.

2. The aurora borealis and the aurora australis are caused by the high-energy particles of the solar wind. When they are trapped in Earth's magnetic field, these particles interact with atmospheric molecules. The colours are indicative of which atmospheric particles are involved.

3. **a.** Nuclear fusion is the type of nuclear reaction that occurs in the Sun.

   b. High temperature and pressure at the Sun's core promotes the nuclear fusion of hydrogen.

   Note: The Sun's immense gravity produces temperatures at its core that trigger nuclear fusion of two hydrogen atoms into one helium atom. Some of the original mass is converted into thermal and light energy during nuclear fusion.

4. To send spacecraft to the outer planets and beyond, NASA uses the gravitational slingshot effect of planets.

5. The noted moons of Jupiter are classified as terrestrial—they consist of solid material rather than gas.

6. Both craft have left the solar system and are still functioning.

7. Textbook questions 1 to 7 from "What Did You Find Out?" on page 411:

1. Jupiter, Saturn, Uranus, and Neptune are most unlike Earth because they are gaseous, while Earth is terrestrial.

2. Mars is most similar to Earth because both planets have thin atmospheres and polar icecaps.

3. Surface temperatures on the planets vary with their distance from the Sun. The farther from the Sun, the colder they are. Venus is the exception. It is the hottest plant because its atmosphere retains heat.

4. Venus is too hot for humans. It also has a poisonous atmosphere, high atmospheric pressure, and no liquid water.

5. The inner planets are rocky, with mountains and valleys and a thin atmosphere. The outer planets, with the exception of Pluto, are all gaseous giants with many moons and rings.

6. The atmosphere of Venus acts like a greenhouse because it traps heat. Its atmosphere consists mostly of carbon dioxide.

7. Pluto is an anomaly because it appears to have a rocky core and an ice mantle. It is small and has an eccentric elliptical orbit which is significantly tilted to the solar system plane.

8. a. Things to consider include the following:

- the size of the craft
- weight
- fuel
- the flight path
- takeoff and landing
- return trip capability
- food
- water
- air
- waste recycling
- low-gravity muscle degeneration
- health and safety
- the effects of people having to exist in close quarters for a long period
- boredom

b. Textbook questions 2 and 3 of "Evaluate," page 417:

2. Answers will vary. Some improvements to the design may include the following:

- The habitat would be supported by a three-legged platform for stability on the irregular surface of Mars.

- Exercise machines would be spring-loaded rather then relying on the reduced gravity of Mars.

- Use modern materials, such as carbon composite materials, for extra strength in the frame of the structure that houses the habitat.

- Use parts for the habitat that can be assembled so that little weight needs to be handled at one time when setting up the habitat.

3. Mars is most suitable for colonization because of the following:

   - It's relatively close to Earth.
   - It has similar physical characteristics to Earth.
   - It likely has a source of water that could be used to produce oxygen and hydrogen fuel.

   Note: Show and describe your display to your home instructor or teacher.

9. **Textbook questions 3 and 5 of "Topic 7 Review," page 419:**

   3. Radar capable of penetrating the dense atmosphere of Venus was used to map its surface.

   5. The booster rockets available at the time Voyager was launched, and even today, are not strong enough to directly launch a spacecraft to the outer planets. Gravitational assists are the only way to attain the required speed.

Section 3: Lesson 3

1. The first person in space was Russian cosmonaut Yuri Gagarin. Alan Shepard was the first United States representative in space.

   Note: John Glenn was the first American to actually orbit the Earth. His orbital speed was about 8 km/s. That's also the speed of satellites in low-Earth orbit. Geostationary satellites orbit at a speed of "only" 3.1 km/s.

2. The Apollo program was designed to get to the Moon with a crew of three people. Project Mercury was designed to place a person in orbit.

3. **Textbook questions 1 to 3 of "Evaluate" and questions 4 and 5 of "Extend Your Skills," page 422:**

   1. Typically, the landing will be harder on the eggs. It depends on the launcher design.

2. If you opt for a parachute landing, the deployment of the chute is critical. Reasons for failure may be due to

    - how the chute is packed
    - the size of the parachute
    - the mechanism of deployment
    - the parachute's material

3. Successful heat shields have good insulating or heat-absorbing properties.

4. Water makes for a softer landing but retrieval is more complicated, because the capsule can sink after being swamped.

5. Underwater vehicles have to provide an atmosphere and protect occupants from pressure and temperature extremes.

4. The major challenge to the Apollo/Soyuz linking mission was making the life-support systems compatible. Each nation had approached the life-support system aboard their spacecraft from a slightly different perspective.

5. People subjected to extended periods of microgravity lose muscle tone due to the lack of gravitational resistance to their movements. They also begin to lose calcium from their bones after a relatively short time.

6. The space shuttle is a re-usable orbiter. It can fly many missions.

7. The most famous Canadian space technology is the Canadarm, used on the space shuttle, and Canadarm2, the second generation robotic arm used on the International Space Station. However, Canadian-designed and manufactured instruments and satellites are involved in many space projects around the world.

8. The International Space Station will provide a long-term research facility for all the sciences. It is anticipated that the microgravity environment will be beneficial in manufacturing processes. Anticipated benefits in medicine are new drugs, a better understanding of the building blocks of life, and the effects of long-term exposure of humans to microgravity.

    Industrial benefits may be improvements in material science (e.g., stronger, lighter materials). Long-term exposure of materials to the space environment will lead to safer, longer-lasting spacecraft. The observation of Earth and the cosmos will be improved. In addition, technological spinoffs will benefit humans in the long-term.

9. The major partners in the International Space Station project are

    - the United States (NASA)
    - Canada (CSA)
    - the European Space Agency (ESA)
    - Japan (NASDA)
    - Russia (RSA)

10. Answers will vary depending on your position. The *for* position might include the following:

- There is a first-hand knowledge of space.
- The effects of space travel on humans and living organisms can be studied.
- The manipulation of some experiments requires a human presence.
- Human involvement bolsters national pride.

The *against* position might include the following:

- Human missions are more expensive.
- Human lives are at risk.
- Observations by humans can be biased.
- Robotic telemetry is more accurate.
- Maintaining life requires a far more complicated ship—this means there are many more things that could go wrong.

11. Textbook questions 1 to 4 and question 7 of "Topic 8 Review," page 428:

1. Astronauts need to be protected from

- an explosive lift off
- the lack of atmosphere
- the cold in space
- increased solar radiation
- the heat of re-entry

2. The space shuttle is re-usable.

3. Canadian astronauts are mission or payload specialists—they conduct experiments or perform a particular mission task.

4. The term *microgravity* is used to describe the effect of free fall. Orbiting objects are in perpetual free fall around Earth.

Note: Human space flight near Earth is mostly in orbits of between 190 km and 580 km above Earth's surface.

Earth's gravity at about 400 km above the surface is still 90% of its strength at Earth's surface. This gravity keeps the International Space Station (ISS) in orbit around Earth. Without this gravity, the station would "fly" away from Earth.

"But then why do astronauts experience weightlessness?" you might ask. "If there is this gravity in space, why don't they feel almost as heavy as they do on Earth?"

Actually, even near Earth's surface, any object in free fall experiences microgravity. A short period of microgravity for an object occurs on Earth by dropping the object from a tall structure. An object in orbit is in ongoing free fall as it follows the curvature of Earth's surface. The microgravity and the weightlessness in the ISS is a result of being in orbit and, therefore, in free fall around Earth. It is not a lack of Earth's gravity that is responsible for the phenomena of microgravity and weightlessness.

7. New technology is developed to improve the understanding of the world that people live in. For example, Galileo improved the telescope to satisfy his curiosity. This curiosity still drives the desire for bigger and better optical telescopes and radio telescopes.

   Political, social, and economic factors influence the development of technology as well. The development of the liquid fuel rocket during World War II and the space race after the war are examples of this type of impetus. The construction of the International Space Station was, and is, influenced by social, economic, and political motives.

Section 3: Lesson 4

Check your answers with your teacher or home instructor.

Image Credits

Cover
middle right: Corbis
remainder: PhotoDisc Collection/Getty Images

Title Page
PhotoDisc Collection/Getty Images

Contents Pages
Section 1: PhotoDisc Collection/Getty Images
Section 2: PhotoDisc Collection/Getty Images
Section 3: PhotoDisc Collection/Getty Images

Page

11 PhotoDisc Collection/Getty Images
12 PhotoDisc Collection/Getty Images
13 PhotoDisc Collection/Getty Images
14 **top:** © 2003–2004 www.clipart.com
remainder: PhotoDisc Collection/Getty Images
15 © 2003–2004 www.clipart.com
17 © 2003–2004 www.clipart.com
18 PhotoDisc Collection/Getty Images
19 **top female:** EyeWire Collection/Getty Images
remainder: PhotoDisc Collection/Getty Images
20 © 2003–2004 www.clipart.com
24 PhotoDisc Collection/Getty Images
25 PhotoDisc Collection/Getty Images
26 PhotoDisc Collection/Getty Images
29 PhotoDisc Collection/Getty Images
31 Digital Vision/Getty Images
32 PhotoDisc Collection/Getty Images
34 © 2003–2004 www.clipart.com
35 © 2003–2004 www.clipart.com
36 PhotoDisc Collection/Getty Images
40 PhotoDisc Collection/Getty Images
41 **top:** PhotoDisc Collection/Getty Images
bottom: © 2003–2004 www.clipart.com
45 **left:** Corbis
right: PhotoDisc Collection/Getty Images
46 PhotoDisc Collection/Getty Images
47 PhotoDisc Collection/Getty Images
50 PhotoDisc Collection/Getty Images
52 PhotoDisc Collection/Getty Images
55 PhotoDisc Collection/Getty Images
56 PhotoDisc Collection/Getty Images

© 2004